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VOL. XVI • NO. 1 • JANUARY 1978

DEVELOPMENT DIGEST

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We would appreciate comments of an editorial nature and suggestions of material for possible inclusion in the DIGEST. Please address:

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1606 New Hampshire Avenue, N. W.
Washington, D.C. 20009

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Use of funds for printing this publication approved by the Director of the Bureau of the Budget June 2, 1966.

For information on how to obtain the DIGEST, see inside back cover.

DEVELOPMENT DIGEST

A quarterly journal of excerpts, summaries, and reprints of current materials on economic and social development

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Renee D. Sumby, Digest Secretary
Prepared by the National Planning Association

for

Agency for International Development, U. S. Department of State

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NUTRITION

GUATEMALAN WOMAN BREAST FEEDING HER CHILD

Policies and Programs to Improve Nutrition

Report of the Executive Director of the
World Food Council

[This article provides a summary of current expert thinking on the nature of the world nutrition problem. It then reviews recent actions taken to attack the problem, which are generally preliminary rather than decisive; and concludes with proposals for the directions which future actions should be taking.]

The events that precipitated the world food crisis of 1972/74 were of a global supply nature. For the first time in more than twenty years world food production declined and food stocks to offset the decline were inadequate. The major concern of the United Nations World Food Conference in November, 1974, was therefore the food supply question. But long before the crisis, in years of relative plenty, hundreds of millions of people had been afflicted by hunger and malnutrition; their lot drew renewed attention at the Conference. During the past two years the global food supply situation has recovered considerably, with stock accumulation occurring in major exporting countries and many food-deficit countries, and export prices for wheat and rice declining to half or less of the heights they reached in 1974/75. Thus, the crisis atmosphere of the Conference seems to be passing. But the "silent crisis" of the hungry and malnourished continues. Their problems have yet to be seriously tackled. The present report was prepared against this background of continuing urgency.

In this report, consideration is given to the need to develop a nutrition strategy which defines the action required and the areas of responsibility within the scope of

The World Food Council is a United Nations body with headquarters in Rome, created following the 1974 UN World Food Conference.

develop a nutrition strategy which defines the action required and the areas of responsibility within the scope of Resolution V of the World Food Conference. [Note: Resolution V called for a comprehensive attack on world nutrition problems, specifying categories for action used throughout this report.]

Dimensions of the Nutrition Problem

Malnutrition generally refers to nutritional disorders arising from four major causes:

(a) Insufficient intake of food causing hunger, with consequent undernutrition.
(b) Qualitatively inadequate food intake causing nutrient-specific disorders such as protein deficiency, nutritional anaemia related to a lack of iron, or xerophthalmia caused by vitamin A deficiency.
(c) Malabsorption of nutrients as a result of a condition or illness either genetic or environmental in origin, resulting in secondary malnutrition; typical examples are intestinal disorders and and infectious diseases, widespread among young children, particularly in poor families, which often lead to severe manifestations of malnutrition.
(d) Overnutrition contributing to obesity, diabetes, hypertension and arteriosclerotic diseases.

Malnutrition implies a measurable pathological state resulting from these disorders. While the first three are closely associated with poverty, the fourth is the result of affluence.

The Nature of Undernutrition and Protein-Calorie Malnutrition. Hunger and malnutrition are the most important and most disturbing manifestation of poverty, and at the same time they contribute - through effects on morbidity, mortality, productivity and physical and mental development -- to the perpetuation of poverty. Perceptions of the nature of the nutrition problem have changed significantly in recent years. Past approaches largely sought technological answers (increasing agricultural production, or development of low-cost protein foods) to a problem which is to a large extent socio-economic and political in nature. Increasing food production can help solve the nutrition problem, but only to the extent that malnourished farmers produce more food and actually consume it, or that increased food production is available to the malnourished non-producers.

The World Food Conference also drew attention to the changing view of the physiological requirements of the human body. Until the beginning of the 1970's, lack of protein had been regarded as the principal

cause of malnutrition. Enormous efforts were invested in the development of unconventional protein sources for human consumption aimed at closing the "protein gap." Yet a critical re-assessment of the available evidence early in this decade has suggested that the problem is lack of calories as much as lack of protein: in diets where calories are adequate, protein tends to be adequate too, except in areas where people subsist largely on starchy roots, tubers or bananas. The basic problem therefore appears to be primarily one of food quantity rather than quality.

Increasing the availability of food to the undernourished is indispensable to the solution of the nutrition problem. But food habits and taboos often deprive vulnerable groups, especially young children and pregnant and lactating women, of available foods they need most. The duration of breast feeding and weaning practices are critical factors, as is the influence of the weaning food inudstry which, through promotion of its products among the poor, may contribute to what has been termed "commerciogenic" malnutrition.

The Magnitude of Undernutrition and Protein-Calorie Malnutrition. The world's state of malnutrition is not systematically studied or measured. Estimates of the number of malnourished have been derived from national aggregates of food availability, supplemented by some information about the distribution of food among groups, and by anthropometric and clinical information. Yet, while existing estimates are only crude approximations, it is well known who the malnourished are. They are the rural poor, particularly those displaced from or with very small amounts of land; and poor urban dwellers. The majority are malnourished principally because they lack the purchasing power to acquire sufficient food or, if they are farmers, they lack the resources or knowledge to produce sufficient food.

There have been a number of approaches to estimating the total population affected by malnutrition. Because failure of growth, sickness and death of children resulting from or associated with malnutrition are easily measured, the number of malnourished children and high rates of child mortality are usually the main indicators of a community or national nutrition problem. The most useful data for assessing the nutritional status of children are those assessed by weight and height attained at a given age. (These measurements cannot distinguish between undernutrition and single-nutrient deficiency.) WHO statistics, extrapolated to the world level, suggest that close to 100 million children up to four years of age suffered from moderate or severe protein-energy malnutrition in the early 1970's. Of these, 70 percent lived in Asia, 20 percent in Africa and 10 percent in Latin America. Pre-school age children constitute about 15-20 percent of the total population in developing countries: thus, these 100 million children may indicate a critical nutrition situation among older children and adults totalling some 500 million.

Another approach involves calculation of the numbers of people unable to purchase sufficient food to meet their energy needs. The International Labour Organization (ILO) study of employment, poverty and income distribution suggests that in 1972 there were 700 million people, or 39 percent of the population in the developing market economies, who could be classed as destitute, i. e. unable to purchase the minimum essentials of food, clothing and shelter. An analysis published by the World Bank suggests even higher numbers, well above 50 percent of the population in developing market economies. These numbers should be interpreted with caution, however. They indicate what fraction of the population is purchasing less than the "average" calorie requirement as defined by FAO and WHO. This figure, based on the assumption of moderate activity of the adult population and on standard requirements for children irrespective of actual body weight, generally leads to overestimates of the magnitude of malnutrition. A different approach has been to specify a minimum point for energy intake below which individuals would be unable to meet their basic physiological needs. Two studies, one in 1961 and most recently by FAO in 1974, although using different approaches to defining the calorie cut-off point, are in agreement that about 15 percent of the world's population, or in 1970 some 450 million people (excluding the Asian centrally planned countries), may be in this critical position.

In comparison with protein-calorie malnutrition, other forms of malnutrition such as vitamin and mineral deficiencies are of lesser importance. Much progress has been made in reducing these forms of malnutrition, but some are still a major public health problem in a number of countries. This is particularly true for vitamin A deficiencies which can cause blindness, iodine deficiencies often leading to endemic goiter, and iron and folate deficiencies often responsible for anaemia. No global estimate of the total number of people affected is available.

The available data and analytical techniques thus provide only a rough idea of the magnitude of the nutrition problem. Gaps in important information have given rise to major disagreements about how large the problem is, how to perceive the problem, and therefore how to proceed to solve it. These gaps and disagreements are an impediment to action, and the World Food Council needs to recognize that at this time, when urgent action is needed, they run the risk of immobilizing action. The Council must strongly emphasize that immediate strategy and program development at the national and international level is possible on the basis of the information which already exists.

Recent Progress in Programs to Improve Nutrition

Food and Nutrition Policies and Plans. The crucial importance of planning for food and nutrition policies as the device for achieving a lasting solution to the nutrition problem is generally agreed. There have been several encouraging developments at the national level. Only a few governments had started work in this area of nutrition be-

fore the World Food Conference, but by now there are nearly a dozen countries which have formulated comprehensive plans and more have begun to do so. Jamaica announced a national food and nutrition policy in 1974. Colombia formulated a food and nutrition plan (PAN) combining rural development and a multifaceted nutrition program, which coordinates activities in the agricultural/rural, industrial (food processing), health, education and social welfare sectors and aims at nutrition improvement through both direct and indirect (employment and income generation) measures. Food and nutrition plans are also being prepared by Senegal, Sudan, Bangladesh and India in cooperation with the Consultative Group on Food Production and Investment (CGFPI). Several developed countries have food and nutrition policy elements. FAO, individually or in cooperation with WHO and UNICEF, is providing nutrition planning support in the context of national planning in Sri Lanka and the Philippines, and in Senegal, Bangladesh, Ghana, Peru, Sudan and Tunisia. Regional interagency cooperation is taking place in both South and Central America, and in the Caribbean. National assistance agencies are supporting nutrition planning activities in a number of countries, and the World Bank has included nutrition planning components in its first two nutrition projects in Brazil and Indonesia.

These activities are in the right direction; but fundamental changes in scale, scope and nature are needed if they are to develop into a substantial attack on world malnutrition within the foreseeable future. Systematic and sustained assistance, offering the range of services required for effective food and nutrition planning to an increasing number of countries, is beyond the capacity of international agencies at the present time. Efforts to develop planning methodology need to go beyond case studies; aid agencies have yet to prepare an effective plan of action for their assistance to governments in food and nutrition planning.

Feeding Programs. The World Food Program (WFP) allocates about a quarter of its total food resources to feeding programs with a primary nutrition objective--supplementary feeding for pregnant and nursing mothers and pre-school children and primary school feeding--with priority for least developed countries. WFP estimates it has reached about 8 million pre-schoolers thus far, a similar number of primary school children, and about 2 million mothers. Presently, WFP supports or has commitments to support supplementary feeding programs in 74 countries. UNICEF assists child nutrition projects in close to 70 countries, benefitting approximately half a million pre-school children and a similar number of older children and mothers. About one quarter of United States food aid under Public Law 480, Title II, was allocated, in fiscal year 1976, to supplementary feeding programs for vulnerable groups, and about 10 percent to school feeding programs, reaching an estimated 14 to 15 million pre-school children and pregnant and nursing mothers, and some 13 million primary school children. Unfortunately there is no way of assessing quanti-

tatively the nutritional impact of these programs in relation to the estimated 100 million pre-school children suffering from severe to moderate malnutrition. In fact, there is increasing concern about how little is known about the nutritional benefits of multi-million dollar expenditures on feeding programs.

Eradication of Micro-Nutrient Deficiencies. Action by governments has concentrated on vitamin A deficiency, nutritional anaemia and endemic goiter, all of which are of major public health significance. WFP and the European Economic Community (EEC) decided to fortify most of the dry skim milk (DSM) donated to developing countries with vitamins A and D. This has been the policy of USAID for several years for DSM and some food mixtures such as corn/soy mix (CSM) and wheat/soy blend (WSB). In Guatemala and Costa Rica, legislation for the fortification of sugar with vitamin A was passed in 1976 and is now implemented. Programs for periodic distribution of large doses of vitamin A are being carried out in the Philippines on a trial basis, in the Sahel countries, in Bangladesh with coverage of about 85 percent of all children up to six years of age, in India covering 6 million pre-school children, and in Indonesia where 200,000 children in Central Java participated in the program in 1976.

To combat nutritional anaemia some industrial countries fortify wheat flour with iron, and Chile and Costa Rica are initiating such programs. Trials on the effectiveness of iron fortification of sugar, salt and other potential "carriers" are underway in several countries, including Guatemala, the Philippines and Thailand. Programs for distribution of iron tablets to pre-school and school-age children and pregnant and lactating women are going on in a large number of developing countries. Programs for iodization of salt are carried out in a number of countries, and alternative measures such as the administration of iodinated oil and the distribution of potassium iodite were recently initiated in Zaire and Sudan, respectively.

Breast Feeding. All major United Nations and bilateral agencies and non-governmental organizations working in the field of nutrition have been concerned about the decline of breast feeding in developing countries because of the serious problems associated with bottle feeding among poor populations. Among the activities of long standing designed to alleviate this problem are support of training of medical and health workers and of mother-child-health services, and joint action through the Protein-Calorie Advisory Group (PAG) mechanism to try to modify advertising and promotion practices for commercial infant formulas. Recently, there have been efforts in several developing countries to use mass media to promote breast feeding. UNICEF is supporting such projects in Colombia and in the

Caribbean. WHO has launched a three-phased research program in breast feeding and infant nutrition, with the results of the first phase becoming available during 1977.

Nutrition Education and Training. Assistance in nutrition education and training is provided by FAO, UNESCO, WFP, WHO, the World Bank and a number of bilateral and non-governmental agencies. It represents an important component of composite interventions in the majority of feeding programs. UNESCO has given particular attention to the promotion and improvement of the quality of nutrition education.

Nutrition Surveillance. The design of nutrition surveillance is important for use in planning action programs at the national and international levels, and evaluation of their implementation. Nutrition surveillance can also provide "early warning" of impending deteriorations of the food and nutrition situation of disadvantaged populations. An FAC/UNICEF/WHO Joint Expert Committee on Methodology of Nutritional Surveillance was formed in Geneva in October 1975, the report of which was published by WHO in 1976. As a result, a number of activities have been initiated, although relatively little substantive progress can be reported.

Applied Nutrition Research (ANR). WHO, partly with UNICEF, conducts field research on methods of control of nutritional anaemia with projects in Burma, Central America, Indonesia and Thailand, and of vitamin A deficiency with projects in Central America, Indonesia and the Philippines, and supports research on the development of homemade weaning foods. The United Nations University pursues ANR activities in the context of its World Hunger Program. There has been a very positive response from the academic community, as indicated by the efforts of the United States National Academy of Science, which, drawing on scientific expertise from around the world, has drafted a $100 million, five-year nutrition research project proposal as part of a World Food and Nutrition Study.

A Concerted Approach to Improving Nutrition

The preceding sections show that a start has been made towards the implementation of Resolution V. A number of countries have taken steps to develop national food and nutrition strategies, and multilateral and bilateral aid agencies have been active in specific areas. But it is also evident that progress overall has not moved far in the direction required by Resolution V: towards a major, concerted approach to nutrition improvement. On the whole nutrition has not received the priority that is publicly proclaimed by the international community. While the new view of the nutrition problem as a major aspect of development is increasingly shared by governments and assistance agencies, its implications

are not reflected in actions taken. Fundamental changes in the scale, scope and nature of efforts are needed if these are to lead to quantitatively significant progress.

A concerted approach demands that governments introduce nutrition improvement as a clear and distinct goal of their development efforts. Food and nutrition strategies that ensure that this is a major intent and expected result of development are the essential vehicle for integrating nutrition concerns into the development process. They also provide a framework for integrating nutrition and health programs into other development measures. And it is through the development of such strategies that knowledge and perception of the magnitude and nature of the nutrition problem will gradually improve.

A Systematic Approach to Nutrition Improvement. The primary concern of food and nutrition policies in developing countries must be to improve the quantity and quality of food consumed by those inadequately fed, and to remove those health and environmental factors closely associated with malnutrition. This will require changes in the direction and pattern of overall development, and of agricultural and rural development in particular. The principal function of food and nutrition policies is to guide this process by orienting sectoral activities towards a development pattern that would ensure the reduction of malnutrition simultaneously with the achievement of other development objectives. The crucial problem to be resolved through such policies is to strike the appropriate balance between nutrition objectives and other development objectives. Food and nutrition planning can be approached in different ways, and the shape, content and complexity of policies necessarily vary according to specific country situations. Techniques for nutrition planning and policy formulation--like techniques for poverty-oriented planning in general--are in an early development stage and confront governments with considerable difficulties. There are, however, simple initial steps available to every government that wishes to adopt a systematic approach to nutrition improvement.

Food and nutrition policy formulation starts with the identification of the nutrition problem. There is a need for improved approaches to problem assessment, corresponding to the view of malnutrition within the broader context of poverty and to the intersectoral nature of food and nutrition policies. And there is a need to define the nutrition problem in terms that are operationally meaningful. Questions aimed at defining the malnourished and the nature of their nutritional deficiencies call for disaggregated, people-specific analysis, as opposed to the more usual problem assessment in highly aggregated national terms. This, and the multisectoral nature of the problem, require new analytical capabilities and multidisciplinary approaches.

Data Collection. Countries have more data relevant to nutrition problem analysis than they may realize. These are generally scattered throughout individual ministries. The first step is to bring these data together and organize them within a multisectoral framework oriented toward nutrition. Thus, developing a planned approach to nutrition improvement need not and should not be postponed until more information is available. Systematic analysis of existing data and the initial planning process itself will identify knowledge gaps and the nature of data requirements for nutrition planning. Promotion of data collection schemes in the absence of a clearly articulated commitment to nutrition planning, however, may prove unproductive because the operational relevance of the data would not be ensured. The calls for more data on malnutrition or on poverty as a whole, which have repeatedly been voiced in international gatherings, are likely to lead to big data collection efforts with few practical results unless uses for the data are specified.

In the course of gradually improving food and nutrition planning, governments will encounter the need to establish or improve food and nutrition data systems. Fast, simple and inexpensive methods are needed for measuring a limited number of characteristics that will define the nutritional status of a population or of individuals; and simple, low-cost, and rapid methods for acquiring disaggregated data on food consumption need to be developed.

Policy and Program Review and Formulation. Food and nutrition planning incorporates two distinct functions: the formulation of national and sub-national food and nutrition policies and plans; and the continuing process of review and appraisal of sectoral decisions and activities in terms of their nutritional impact. Particularly in the early stages of nutrition planning, overemphasis on formulating comprehensive policies--and thus concentration on carrying out the studies required--runs the risk of overlooking important immediate opportunities for action to reduce malnutrition. The most important initial opportunities lie in pursuing activities pertinent to the second function, by the appraisal of nutritional impact of policies designed for other purposes, especially in the agricultural sector, and by a critical look at ongoing feeding programs.

Much less is known about the direct nutritional impact of nutrition intervention programs than should be known, considering the long history of such programs. From the limited analysis which exists, it would appear that programs with explicit nutrition measures often had little relevance to the actual nutrition problem (by failing to reach undernourished people), or did not yield the results that could have been achieved had these programs been better designed. In the agricultural sector, a review of the nutrition impact of food production schemes may reveal whether they

benefit the malnourished or aggravate their problem. Large-scale, capital-intensive dairy projects, for example, designed to increase protein production, may supply only urban middle and upper-income groups, at the same time displacing rural labor and decreasing the incomes of those at greatest risk of malnutrition. But the inclusion of nutrition and other poverty-related considerations in project planning may make them the most important yet undertaken to improve the nutritional status of the least privileged groups, as in the case of the WFP-assisted project "India 618 - Milk Marketing and Dairy Development". This type of evaluation can quickly be done by most governments and would yield early, relevant nutritional benefits.

Much can be done with existing techniques to orient sectoral policies towards nutrition objectives. But there are limits to the extent that these techniques permit an assessment of the impact of alternative patterns of development--and of agricultural/rural development in particular--on the evolution of the nutrition problem. In the agricultural sector, there is a need for improved methods to predict the impact on food consumption and nutrition of alternative decisions concerning agricultural and particularly food production. This is an area that deserves priority attention in the development of approaches to food and nutrition planning. Topics of immediate practical importance include the nutritional consequences of alternative farm price policies for agricultural products and inputs; alternative cropping patterns, and alternative forms of production; and alternative domestic consumer price or subsidy policies. High prices which stimulate production by farmers diminish food access of low income consumers, for example.

National food and nutrition policies need to take account of the local and regional economic, social and political factors affecting malnutrition in order to develop specific approaches to the problem at these levels. National policies thus need to be translated into specific local programs, and to be composed of local program elements made consistent with overall national objectives. "Area level" approaches to development planning exist in a number of countries, and nutrition planning could be introduced into the existing planning structures. For many countries, however, the need for disaggregated food and nutrition planning will mean significant changes in the national planning procedures.

Organizational Requirements for Food and Nutrition Planning. The multisectoral nature of a planned approach to nutrition improvement necessarily has implications for institutional arrangements in planning and decision making. The customary division of nutrition responsibilities among several ministries leads to ineffective policy formulation. Ministries assigned nutrition responsibilities may not always be capable of influencing those policies and programs which

critically affect nutrition, especially since their concern for nutrition may be overshadowed by other priorities within the ministry itself. Specific provisions are needed for the formulation of overall nutrition objectives and goals, and for the monitoring of the problem in ways which allow adaptive control.

Many governments have responded to this need with the establishment of national nutrition commissions, or inter-ministerial committees; but few of these have managed to cope effectively with the demands of intersectoral food and nutrition planning. A body is needed which: a) is so placed that it can affect the decisions of the central planning body with regard to the programs and budgets of ministries; b) has the capability for independent analysis; and c) has the capacity to assist the ministries in identification, design and appraisal of programs. Such a body will need sufficiently high authority for it to be taken seriously, both within the ministries and at higher policy-making levels.

The financial and manpower implications of such organization structures, however, are small. A food and nutrition planning body can operate effectively with a small multi-disciplinary team. Much of the work for it should be done by national institutions and ministries. The primary need is a political one: a full-fledged commitment to the eradication of hunger and malnutrition through the adoption of a systematic approach to nutrition improvement, and the acceptance of the implications this entails in terms of changes in the planning and decision making process and in terms of changes in the balance between nutrition improvement and other development objectives.

Composite Intervention Programs. Nutrition intervention programs will be needed in most countries for a long time to come, to provide a short-cut to nutrition improvement until fundamental developmental measures take effect and to support those measures on an on-going basis. But if this is to be achieved, intervention programs must go beyond those of the past. Although this is now generally recognized, there is much uncertainty about the precise types of interventions needed under varying conditions.

While there is an increasing awareness of how little is known about the nutritional impact of feeding programs and nutrition education, a concensus is nevertheless emerging regarding necessary shifts of emphasis. In the past, feeding programs tended to be biased towards school children. However, children of school age are now regarded as beyond the age of greatest risk of malnutrition, and if they are in school they may already represent a relatively more favored group. If children of school age have suffered malnutrition at an earlier age the changes in physical

and possible mental development produced are not easily reversed. The recognition that school meals do not attack the core of the nutrition problem is leading to a significant shift of emphasis towards the feeding of younger children, particularly in the critical 6-36 month age group, and of pregnant and lactating women. Moreover, an improved understanding of the multiple causes of the nutrition problem, and consequently of the need for many-sided measures to correct the problem, has resulted in increasing emphasis on more complex intervention packages providing services in the fields of food, nutrition, health and often family planning. This is essentially the approach now taken by FAO, WFP, WHO, UNICEF and the World Bank, although the composition and complexity of these programs varies considerably.

Common features of "package interventions" in Brazil, Colombia, Costa Rica, India, Indonesia, Korea, Panama, the Philippines and a number of other countries include:

- supplementary feeding to vulnerable groups;
- health protection, including immunization of children, provision of vitamins and minerals either directly or by food fortification, and in some cases environmental sanitation;
- nutrition and health education;
- food production, storage, processing based on home/school/community gardens with assistance from agricultural extension services, sometimes accompanied by programs aimed at raising agricultural production of small farmers;
- family planning (in some cases).

If these programs are to make a quantitatively significant impact on nutrition--which has not been the case with most applied nutrition programs in the past--they must reach the majority of the under- and unserved rural communities of the developing countries where the nutrition problem is particularly severe. This, in turn, will depend on an effective administrative structure linking communities with their central governments, and on the successful involvement of the communities and their people. There are promising examples that this can be achieved, as indicated by the Philippine Nutrition Program, which works through nutrition committees at the regional, provincial, municipal and barangay (group of 20 households) levels, with volunteer community workers keeping the nutrition situation of a barangay under surveillance. Positive examples of using community workers for simple nutrition surveillance and the delivery of primary health and nutrition services have also been reported from Colombia, Bangladesh and India. Moreover, there are indications that composite

interventions can be mounted at reasonable financial cost and that the primary problem therefore is one of political commitment and of administrative capacity. Thus there is evidence--however fragmentary--that much more can be achieved through intervention programs than past experience suggests. But the present largely scattered efforts are insufficient to provide conclusive guidance for action in the near future, and this has resulted in substantial disagreements over the relative effectiveness of different programs, thereby delaying more widespread action in this area. The United Nations system should provide immediate leadership in this field.

[Extracted from Policies and Programs to Improve Nutrition, Report of the Executive Director to the Third Session of the United Nations World Food Council at Manila, June 1977.]

Colombia's Food and Nutrition Plan

Clara Eugenia Lopez

[Colombia is a country in which the government has taken a searching look at its nutrition problems, and has adopted a plan for comprehensive action in which the improvement of nutrition is given strong priority. This article outlines briefly the conditions in Colombia and the nature and scale of the actions to be taken.]

This paper describes the evolution of concern for the problem of malnutrition in Colombia. Starting in the mid-1940s and continuing through the 1960s, serious studies were carried out by nutritionists which revealed the magnitude of the problem and its interdependence with income distribution, education, health, and agricultural production. It is presently estimated that for 30% of the Colombian population income is a barrier to proper nutrition. Furthermore, there is evidence that about 60% of the children in Colombia suffer from some degree of malnutrition with consequent irreversible effects on physical and intellectual development. The present government has identified the problem of malnutrition as the one that requires the most urgent attention among the priorities for development policy. The government, therefore, has been designing an integral food and nutrition plan which will be the axis of the country's development policy for the next few years. This plan calls for the execution of concrete projects in just about every sector of economic and social activity: education, health, agriculture, industry, commerce, transportation, public construction, and so forth.

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The Nutritionally Vulnerable

Studies of malnutrition in Colombia have identified, in order of importance, the following principal types of problems: 1) protein-calorie malnutrition in infants and children; 2) chronic subnutrition in adults; 3) widespread vitamin A and some vitamin B deficiencies; 4) anemia caused by iron deficiency; and 5) dental infections. Endemic goiter, which several years ago was common in various regions of the country, has practically disappeared since iodization of salt was introduced in 1959, and enforced in 1963.

Magnitude of the Problem. The latest available food balance sheet based on 1972 data shows a significant deficit of the major foodstuffs and nutrients on a per capita basis. Figures for actual national consumption as a percentage of recommended levels for the same year reveal:

In terms of nutrients:

Calories	104%	Vitamin A	73%
Protein	83%	Thiamin	95%
Calcium	91%	Riboflavin	77%
Iron	100%	Vitamin C	213%

The food and nutrient situation is more critical for the members of the lower income groups for whom their income level, and not overall food availability, is the principal barrier to adequate nutrition. Comparing consumption data for two income groups from the National Household Survey (1970) with the Family Welfare Institute's minimum consumption recommendations (1975), the following results were obtained (see Table 1).

Table 1: Percentages of Actual Average Consumption in Two Income Groups in Colombia as Compared to Minimum Recommended Levels for Specified Foods and for Total Calories and Protein, 1970.

	Calories	Protein	Milk	Meat	Legumes	Cereals	Tubers	Fats
Low Income* Level I	70	61	51	66	34	62	61	60
High Income* Level II	112	103	88	118	58	106	93	116

*Level I has family incomes below 18,000 Colombian pesos (US$940) per year; Level II family incomes are above 18,000 pesos.

Sources: Household Survey, National Department of Statistics, 1970; Provisional Recommendation for Food Consumption, Family Welfare Institute, 1975.

As can be seen, families in income level I, which represent 30% of the country's population, consumed only 61% of the minimum recommended level of protein and 70% of that of calories. Families in income groups earning above 18,000 pesos annually do not show consumption deficiencies in terms of calories and protein, although some underconsumption of specific foods is observed.

Malnutrition in children, however, does not respect this classification. Results from nine nutrition surveys carried out by the Nutrition Institute in the 1960s showed that 66% of children under 5 years of age suffered from some degree of malnutrition as follows: first degree malnutrition 45.6%, second degree 19.3%, third degree 1.7%. Of the undernourished children, 51.6% were under one year old and 73.6% were under four. Absolute numbers show that some 90,000 children under five die each year, more than one third of these from causes related to malnutrition. Of the total number of deaths that occur in the country each year, 43.1% are of children under five years old, an age group which represents only 18% of the population. Children under one year old make up only 3.9% of the population and account for 27.6% of registered deaths.

Adult subnutrition in Colombia represents the second most important nutrition problem, and it is manifested in work absenteeism, lack of initiative and ambition, and in other measures of labor productivity. The health ministry has estimated that about 96 million work days are lost each year due to illness, which, at the present minimum salary, represents 3,840 million pesos (US$128 million), without calculating costs of medical care, reduced worker efficiency, residual crippling or years lost through premature death.

The Health System and the Nutritionally Vulnerable. The principal cause of death in children under 14 years of age is the group of gastrointestinal and diarrheal illnesses. Since most of these diseases are transmitted by water, inadequate provision of aqueduct and sewage services has serious effects on the health status of the population, especially in rural areas. At present, only 29% of the rural population has access to potable water, and 73% of the urban population. In Colombia, the private sector provides medical attention to 15% of the population, and social security institutions provide care for another 10%. The remaining 75% of the population is, in theory, covered by the government health services. In fact, however, these services at present reach only 39% of the total population. The country has 12,000 doctors, or one for every 2,083 persons. Their geographical distribution is so uneven that 74.2% of them provide their services in departmental (state) capitals containing only 35% of the total population, while 80% of the dentists and 86% of the trained nurses are located in these cities. Although a large effort has been directed in the last few

years to the training of paramedical and auxiliary personnel, these workers cover only one-third of the rural population.

Food and Agricultural System

The agricultural sector is of primary importance to the economy. Its contribution to the gross national product was 25.9% in 1973, the largest of any sector. Agricultural products, chiefly coffee, cotton, sugar, meat and bananas, account for more than 60% of the country's total exports. With the exception of wheat and fats, Colombia is practically self-sufficient in food commodities. Small quantities of corn, barley and cacao are imported yearly, but do not require substantial expenditure of foreign exchange earnings. Food imports represented 11.3% of total imports in their peak year, 1973. A government subsidy for the price of imported wheat has since been abolished, which should stimulate internal production and diminish the need to import.

The agricultural sector grew at an annual average rate of 3.2% between 1950 and 1974; more recently there has been a faster pace--5.5% in 1972, 4.5% in 1973 and 5.0% in 1974. The two subsectors of agriculture, modern and traditional, have had very unequal development since 1950. The modern subsector of commercial crops, primarily for industrial use or for export, has experienced rapid growth between 7% and 8% annually since 1950. This resulted from the ample credit made available to this subsector, the development and adoption of high-yield technologies, and the application of modern management skills. The traditional subsector, on the other hand, which produces 55% of the foodstuffs consumed by the population, is characterized by low productivity, poor soil, small land holdings, scarce credit, and scarcer application of modern technologies. As a consequence, the traditional sector has tended towards stagnation, with consequent negative effect on food production. Since 1973, despite 5.0% annual growth of total farm production, the increase in commodities destined primarily for domestic foods barely exceeded the estimated 3.2% rate of population growth. Food price rises have been one of the major components of national inflation.

Colombia has had a policy of agricultural support prices since 1944, as well as some consumer price ceilings. Support prices have been intended to stimulate production by assuring farmers a minimum income, and to stabilize food prices through the accumulation of buffer stocks at the support prices. The state agricultural marketing agency, known by its initials IDEMA, buys part of the crops of rice, wheat, corn, beans, soybeans, sorghum and sesame; but its limited financial and storage capacity has resulted in effective intervention only in the case of rice. A recent study indicates that government intervention in

this instance has increased production by 10% annually since 1960, and has stabilized incomes received by rice farmers (rice in Colombia is a commercial crop belonging primarily to the modern subsector of agriculture).

In 1972, the government adopted a policy subsidizing wheat consumption by keeping internal prices below those of the world markets: internal production therefore diminished, and consumption was considerably increased. Recently, however, this subsidy was eliminated, and wheat production as well as consumption appear to have responded appropriately. Effective price controls exist only for sugar, milk and coffee. In the case of sugar, the Price Board fixes a ceiling for the price at which sugar can be sold to the public: this ceiling proved effective between 1960 and 1972, and even with higher external prices since then it has restrained the increases. In the case of milk, IDEMA buys 20% of production, at a price frozen at one-half the market price, for sale in low income areas of the main cities. The rest of the milk is marketed through private commercial channels and no limit is placed on its sale price. The coffee price policy is aimed at assuring adequate incomes to coffee growers by mitigating the effects of large fluctuations in international prices.

About half of the country's labor is employed in the agricultural sector. Over 70% of these are landless or live on sub-family-sized farms. About 25% of the agricultural working people are unemployed or work in marginally productive jobs. Income distribution in rural Colombia is uneven and skewed. The upper 10% of the rural working population earn 51% of the agricultural sector's income, whereas the lowest 10% earn only 1.4% of that income. A similar though less extreme situation is found in urban areas. Services such as health and education are more readily available in the cities than in the countryside. In the most comprehensive study to date on income distribution in Colombia, recently published by Albert Berry and Miguel Urrutia, the authors reached the conclusion that the uneven distribution of income in the agricultural sector is largely due to the uneven distribution of land ownership.

Existing Nutrition Programs

Iodization of Salt. Although made mandatory by Law 44 of 1947, provisions for its enforcement were only introduced in 1963. Since that date, endemic goiter, previously quite widely distributed, has disappeared, ceasing to be one of the primary health and nutritional problems of the country.

Nutrition Institute. Originally created as a Division of the Health Ministry in 1947, the Nutrition Institute became an independent entity

in 1963 with its own funds, derived from a percentage of the revenue from sales of iodized salt. In 1968, it was incorporated as a division of the newly created Institute of Family Welfare (ICBF). By conducting many studies of the problems of malnutrition, the Institute created public consciousness of this problem throughout the 1960s.

PINA Feeding Projects. The contribution of international food aid to nutrition programs in Colombia has been substantial. Food aid was given in kind and thus determined the scope of the programs initiated, limiting them primarily to supplementary feeding. This process can be seen in the Integrated Program of Applied Nutrition (known as PINA). These programs, initiated in many nations, were designed with a multisectoral approach by food and nutrition experts from various countries and FAO, WHO and UNICEF. In Colombia, the first PINA project was initiated in 1960 in Caldas, and the program slowly spread to cover 14 departments by 1970; it now includes all 22 departments. The objectives were: 1) to define the nutritional problems of the population; 2) to encourage agricultural production and improve family life through the promotion of agricultural extension and home economics; 3) to develop nutrition education activities; 4) to improve the health of the population through prevention and treatment of malnutrition; and 5) to integrate all public and private activities in the field of nutrition.

The first objective was achieved with the execution of a series of surveys and studies which still represent the basic sources on nutrition in the country. Success in other goals, such as the improvement of family life, is hard to measure, and the proposed agricultural credit and extension actions have had limited expansion due to lack of financing. The major achievements of the PINA programs are in the fields of nutrition education and distribution of food supplements to mothers and children under seven years old. According to PINA statistics, 37% of those attending primary school now receive a food supplement in school. The food supplement provides 35% of the child's daily requirements and consists of milk, fish, corn and wheat meal, oil and vegetable mixtures. Preschool children get their food supplements from health posts: in 1974, 575,240 children benefited from the program. The food supplement for these children represents 45% of their daily requirements and consists of milk, legumes, vegetable mixtures, and oil. Since its distribution is accompanied by health and nutrition education, as well as by a food supplement for mothers covering 30% of requirements, the effect on the child's diet should be even greater.

These food supplements are mainly composed of food aid from WFP, CARITAS, and CARE. For the period 1970-74 this aid amounted to about $27 million yearly. Since 1975 food aid has been decreasing gradually and will cease altogether by December 1978. Colombia is

taking the necessary steps to substitute domestic production for all foreign food aid. This process is part of the National Food and Nutrition Plan, examined below.

The New National Food and Nutrition Plan

The innumerable studies and observations on the gravity of the problem of malnutrition in Colombia over the past two decades have demonstrated to nutritionists and policymakers alike the close interdependence between nutrition, health and the country's social and economic development processes. It has become clear that malnutrition and associated illnesses have severe impact on the whole economy, and that the agricultural and educational sectors especially have impacts on nutrition levels. However, no previous plans had approached the problem with the integrated nationwide effort of the present National Food and Nutrition Plan.

The economic growth process that "took off" in Colombia in the 1950s and has continued to the present was industrial in orientation. The agricultural sector was given inadequate attention, as shown by its slow growth and the increasing exodus of people from the countryside. From the beginning of his political career, President Alfonso Lopez Michelsen advocated a better treatment of rural Colombia, especially of the traditional sector which had been on the fringes of the country's development process. When elected in April 1974, Dr. Lopez called together a team of Colombian experts, primarily economists and engineers, to study specific national questions: among others, the problems of malnutrition, of incorporating the traditional farm sector into the country's development process, and of raising minifundista (small farmer) incomes. Heavy emphasis was placed on the inequity of malnutrition for the children who will suffer its irreversible effects. This is a special burden to low income families especially prevalent in the rural sector.

By putting these two major problems--nutrition and rural income--together, the idea of the National Food and Nutrition Plan was conceived. To raise minifundista incomes, substantial resources were to be directed to the traditional sector in the form of credit, technical assistance, services (health, education, etc.) all aimed to raise the productivity of their labor. In order to avoid the scenario of increased productivity, leading to higher production, then falling prices and lowered income, a new market had to be found for the additional foodstuffs that would be produced. This market would be provided by a nationwide effort to improve nutrition; the state could be one of the future buyers of additional produce generated by the transfer of resources to the traditional agriculture sector.

One year after the new administration was in office an all-encompassing plan had been designed, and was enacted March, 1975. The Food and Nutrition Plan represents a massive effort to eradicate malnutrition through concrete actions carried out in an integrated way by the various entities of the Colombian government with the financial collaboration of international agencies (World Bank, IDB, AID, etc.). Primary effort will be directed to the agricultural sector in order to increase the output of food, particularly beans, green peas, soybeans, rice, corn, wheat, potatoes, yucca, plantain, fish, poultry and pork, as well as other small farm animals. This strategy will be oriented specifically towards increasing the productivity of farmers with little land, the minifundistas of the traditional sector who produce over half of the food consumed in the country. Through a series of Integral Rural Development Projects, located in the minifundio and poorest areas of rural Colombia, large quantities of resources are to be invested where the state has been conspicuously absent in the past. Projects include the building of basic infrastructure such as country roads, local storage facilities, rural aqueducts, and rural electric lines, and the extension of the basic government services of health and education. These facilities will be accompanied by substantial transfers of credit and technology to the small farmer sector and by land reform, which will undoubtedly increase the production of food, both through increased productivity per acre and increased area cultivated. Along with the Integral Rural Development Projects which benefit the poorest areas, a massive extension of credit is planned at the national level for the entire agricultural sector, including the commercial subsector. Through these projects, a partial solution is reached for both urban and rural areas, as more foodstuffs reach the cities and small farmer incomes grow.

The second main area of emphasis for the Food and Nutrition Plan is nutrition education. Traditional Colombian diets are surprisingly good in nutritional terms; but due to artificial pricing mechanisms and consumer-oriented propaganda on the radio, many of these diets have been abandoned. A return to tradition may prove a considerable nutritional bonus in the short run without requiring increased expenditures on food. A nutrition campaign through the mass media is therefore being designed which will compete with nutritionally counter-productive messages and encourage the return to traditional consumption and breast-feeding practices. Concurrently, programs of interpersonal and institutional education are being started through health personnel, and at all levels of formal education.

A third field of action will be that of marketing. As in most developing countries, great quantitites of food are lost, with a resulting rise in prices. Through the construction of local storage facilities and the improvement of transportation, as well as through the encouragement of central wholesale markets in the cities, increases in the food supply and decreases in marketing costs will be sought.

The industrial and commercial sectors have an important role to play in production and commercialization of highly nutritive, low-cost new foods. The Institute of Technological Investigation has developed and adapted technologies for producing texturized vegetable protein, vegetable mixtures, fortified pastas, soybean milk, and so on. The government will provide financial and technological assistance to private firms to stimulate production of these new foods and their distribution through existing commercial channels. Part of the mass media campaign will be directed to promoting the new foods in family diets. Legislation will be proposed to Congress which will control advertising, protecting both the consumer and the new food producers from false claims of a product's nutritional value. State purchase and subsidy of a proportion of the output of these products will provide a guaranteed market for the industrialists. This is perhaps the most important element in securing the private sector's collaboration with the plan. The raw materials required for the new foods will all be produced in sufficient quantities in Colombia (soybean, corn, wheat and rice meals, skim milk) as a result of the agricultural sector strategies. The use of these products as inputs to the new foods will absorb a proportion of the increased food production by the traditional agricultural subsector, thus helping to prevent price declines. And these new products will substitute, to a great extent, for the food aid presently provided by international agencies.

Another important component of the Food and Nutrition Plan is the extension of health services and the provision of clean water. Not only are intestinal diseases an important cause of mortality, but they limit the efficiency of nutrient absorption. Since the principal source of these diseases is contaminated water, a great effort is planned to bring potable water to small rural villages and to the countryside. Furthermore, the Ministry of Health is planning a massive extension of services. Health posts are to be brought to remote rural areas, and some 6,000 paramedical and rural promoter personnel are to be trained. This latter group is made up mostly of women trained in basic health, sanitation, and nutrition practices who work in the communities or at health stations. They relay sick people and expectant mothers to the health post where auxiliary personnel diagnose and give treatment. Serious cases can be then sent either to hospitals or to health centers which have permanent doctors and more sophisticated equipment, depending on the gravity of the patient's condition.

Finally, the Food and Nutrition Plan contains a supplementary food distribution program as a component of the health services. Food supplements are for children under two years old and for expectant and lactating mothers in the 10 to 20 percent poorest segment of the population. This is considered a temporary subsidy, amply justified until family incomes of this group rise to an adequate level. Food

distribution will be carried out through the channels developed in the past with the international food programs. A second part of the food supplement program consists of the distribution of new foods through the commercial channels, to be purchased by mothers with a subsidy in the form of a coupon. The coupons will be distributed by the health personnel to mothers who have children under two years of age, who are pregnant, and whose income does not permit an adequate level of nourishment. The coupon will represent a fraction of the purchase cost of any of the new foods placed on the market. The store owner will in turn use the coupon he has received as partial payment to restock his supply of new foods. The industrialist will be able to exchange the coupons he receives from intermediaries for money at any of the state-owned financial institutions. Aside from guaranteeing a market for the new foods, the coupon system will be an effective tool in transferring resources to the poorest members of society. Even if it is misused, by resale for instance, it will still represent a net resource transfer to poor groups, a large proportion of which will be spent on food.

Table 2: Estimated Costs of the National Food and Nutrition Plan
Colombia
(in U.S. $ millions)

Production of New Foods	$52.3	
Subsidized Food Distribution	51.3	
Direct Distribution		17.9
Coupon System		33.3
Fishing	3.6	
Agricultural Credit	80.0	
Integrated Rural Development Program	27.0	
Nutrition Education	17.3	
Health	98.1	
Water Supply		43.3
Health Centers		4.7
National Health System		50.0
TOTAL	$572.6	

[Extracted from a chapter of Nutrition and Public Policy, Beverly Winikoff editor, to be published spring 1978, Copyright © The MIT Press, Cambridge, Mass.]

The Crisis in Infant Feeding Practices

Alan Berg

[There is increasing evidence that the trend away from breast feeding of children in developing countries has taken its toll in increased numbers of infant deaths and cases of malnutrition, and in costs to the family and the nation. The importance and the beneficial effects of breast feeding are stressed here, along with policy suggestions on how it could be encouraged.]

The Economics of Breast Feeding

Breast feeding is the traditional and ideal form of infant nutrition, usually capable of meeting a child's nutritional needs for his first four to six months of life. Even after the introduction of supplemental foods, human milk can serve as an important continuing source of a child's nutritional well-being. From the sixth to the twelfth month it can supply up to three-quarters of a child's protein needs, and a significant portion for some months beyond. For most infants in low-income countries, prolonged breast feeding is vitally necessary to growth and, quite often, survival, as it represents the only easily available source of protein of good quality containing all the essential amino acids.

Monetary Values. The child who is nursed through the first two years of its life receives an average of 375 liters (396 quarts) of breast milk. That is nutritionally equal to 437 liters of cow's milk, which would cost about $65, a not insubstantial portion of most family incomes in developing countries. [Note: the dollar values discussed here were assigned in 1973 and would presumably be higher today.] A laborer in Uganda may need to spend as much as 33 percent of his daily

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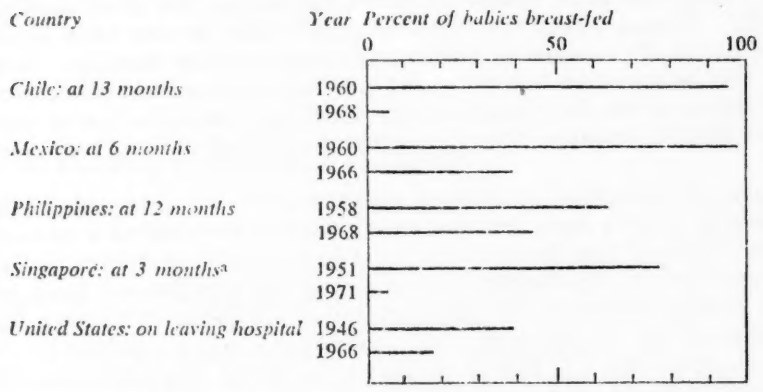
wage to feed his baby milk; in Chile, 20 percent; in Tanzania, 50 percent. For packaged dried milk formulas, which increasingly are finding their way into food stalls of local bazaars, the cost would be close to $140. These costs for commercial milk do not take account of any waste or of diversion to other members of the family. Nor do they reflect the bottle-fed baby's need for bottles and nipples, cooking utensils, refrigeration for fresh milk, fuel; and medical care costs are often ten times greater than for breast-fed babies.

Yet in many developing countries mothers are abandoning breast feeding. Twenty years ago, 95 percent of Chilean mothers breast-fed their children beyond the first year; by 1969, only 6 percent did so, and only 20 percent of the babies were being nursed for as long as two months. Potential breast milk production in Chile in 1950 was 57,700 tons, of which all but 2,900 tons, or 5 percent, were realized. By 1970, 84 percent of the 93,200 potential tons were unrealized. The milk of 32,000 Chilean cows would be required to compensate for that loss. In Kenya, where the decline in breast feeding is less dramatic, the estimated $11.5 million annual loss in breast milk is equivalent to two-thirds of the national health budget or one-fifth of the average annual economic aid.

In the few developing countries where surveys of breast feeding have been conducted over the years, the common pattern is one of significant decline, as shown in Figure 1. In Singapore, between 1951 and 1960 there was a decrease from 71 percent to 42 percent of children in low-income families breast-fed at least three months; the implied loss in the rejection of mother's milk for babies under a year old was $1.8 million. By 1971 only 5 percent of the babies were not weaned by age three months. In the Philippines, 31 percent fewer mothers nursed their babies in 1968 than a decade earlier; the $33 million waste for that year is nearly double the $17 million waste of 1958. In Colombia, as breast feeding of babies from birth to eleven months declined, milk imports increased rapidly; in 1968, they were seven times greater than the 1964-67 average.

The estimated costs of breast milk losses would be lower if the additional calories recommended for a lactating mother were taken into account. But poor women in poor countries seldom get an enlarged or special diet during lactation. When extra food is consumed, it is usually much less than is recommended. If a mother were to eat all the additive calories recommended during nursing--and efforts should be made to encourage this--the cost would still be less than a third of that necessary to provide artificial feeding to the infant. Generally, breast feeding is satisfactory for the infant even without extra food for the mother, but the child's need is met at the expense of the mother's tissue, a very real health cost.

FIGURE 1. *Extent of Breast Feeding in Selected Countries and Years, 1946–71*



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a. Low socioeconomic class only.

Losses in Urban Areas. In most low-income countries, breast feeding is the general rule in rural areas. Its abandonment is primarily an urban phenomenon, often not so much because urban mothers work as because bottle feeding is one of the sophistications of city life the urban migrant adopts. Three-quarters of all mothers in the rural Punjab still breast-feed twenty months after delivery, half at twenty–six months, and a quarter at thirty-three months. In major Indian cities, however, approximately a third of the mothers either do not begin nursing or discontinue it within a year. This rural-urban pattern is consistent throughout the poor countries of the world. In Guatemala, 98 percent of rural Indian babies continue to be nursed after their first birthday, compared with 57 percent of urban children. In Indonesia the comparable figures are 90 percent and 70 percent. In Taiwan, 97 percent of rural mothers breast-feed their offspring for six months compared with 61 percent of their urban counterparts.

The concentration of the loss of breast feeding in urban environments is important because cities in developing countries are undergoing mammoth growth. In addition, as communications techniques become more effective, city habits and life styles will have an increa-

sing influence on rural societies. In rural Mexico the decline in breast feeding is already being felt: between 1960 and 1966 the percentage of babies under six months of age who were fed only by breast milk in one rural Mexican community declined from 95 to 73.

An estimated 87 percent of the world's babies are born in the developing countries, about a quarter of them in urban areas. If 20 percent of the estimated 27 million mothers in urban areas do not breast feed, the loss in breast milk is $365 million. If half of the other 80 percent do not continue to breast feed after the first six months, the total loss reaches $780 million. These estimates clearly understate the situation; losses to developing countries more likely are in the billions.

Breast Feeding as Birth Control. In terms of national development, lactation has another major economic asset--its link to family planning. As a key to child survival, better nutrition through breast feeding may be an important precondition for reducing birthrates. Another benefit of breast feeding is its role in limiting conception; in some societies, in fact, it may constitute a major form of contraception. Breast feeding seems to offer better protection against pregnancy for up to ten to twelve months than does the sort of haphazard and ineffective contraception practiced in many places. The pregnancy-preventing effect of lactation is firmly rooted in the folklore of unsophisticated societies. Recent studies have lent credence to the notion. One investigation reported that the incidence of pregnancy in the first nine months after childbirth of nonnursing mothers was twice that of mothers who breast-fed, including those who simultaneously used other foods. Others confirm that, while breast feeding does not serve as a perfect contraceptive, the risk of pregnancy is relatively small for mothers whose babies receive only breast milk.

The contraceptive value of lactation is most effective if in the first four to six months the infant receives only human milk, for the sucking stimulus appears to inhibit ovulation. In the lactating mother, menstruation and ovulation are delayed from ten weeks to as long as twenty-six months. In Taiwan it was estimated that lactation prevented as many as 20 percent of the births that would have occurred otherwise. In India the same ratio would mean prevention of approximately five million births each year. And in some areas of the world where breast feeding is regarded as essential to a baby's survival, social custom limits sexual intercourse for lactating women, thus reinforcing the link between breast feeding and contraception. Intercourse is avoided as long as one year after giving birth in parts of India, for two years in New Guinea, and twenty-seven months in Nigeria.

Costs in Infant Health

Just as breast milk can be the major source of nutrition, the failure to provide breast milk is a major cause of infant malnutrition and mortality. But just as premature weaning is harmful, human milk unsupplemented with other foods is, after four to six months, inadequate both in protein and calories. Discontinuance of nursing implies an alternative source of food, which in the early months is often in the form of a nutritionally inadequate substitute, such as barley water or cornstarch and water. Milk "formulas", when used, usually are mixed with contaminated water and offered in an unclean bottle with a crusty nipple. (One investigation, for example, found that 80 percent of bottles examined had a high bacterial contamination.) The reasons are clear: poor parents usually cannot afford sustained purchases of commercial milk and as a result commonly dilute it with water, or they substitute for it (in Indonesia, with rice fluid costing a half cent per kilogram). Their lack of education prevents them from reading or understanding the instructions for preparation and, together with ignorance of sanitary requirements, fosters a high incidence of illness. Even mothers aware of hygienic needs often find it difficult to meet them with limited and unclean water, inadequate fuel, poor storage, and a single bottle and nipple. For these reasons, bottle-fed infants have illnesses, especially diarrhea, more frequently, more severely, and earlier than breast-fed babies. Diarrhea occurred ten times more frequently in a group of nonbreastfed Mexican children than in a group of breast-fed children.

Bottle-fed infants also have a much higher mortality rate than those exclusively breast-fed. According to a 1970 study in San Salvador, three quarters of the infants who died from the end of the first through the fifth month had been breast-fed less than thirty days, if at all; of those who died in the last half of the first year of life, slightly over half had been breast-fed less than a month. A similar study in Recife makes the point even more dramatically: 79 percent of the children who died in the second through fifth month had been breast fed less than a month; 70 percent of those who died in the ensuing six months, and 60 percent in the following four years, had been nursed for less than a month or not at all. Deaths of children from diarrheal diseases (which are usually nutrition related) in Recife, where only 22 percent of the children were breast-fed at least one month, were nearly three times the rate in Kingston, where the corresponding figure is 73 percent.

As breast feeding has decreased over the past two decades, the average age of youngsters suffering from severe forms of malnutrition has also dropped--from eighteen to eight months. Since malnutrition in the early months of life is most critical to brain

development, this lowering of the average age of severe nutritional deficiencies takes on special significance.

The Practice of Breast Feeding

Historically, human milk has been universally recognized and revered as the only means of infant feeding. Frequent references to it are found in religion, folklore, and value systems. The Koran prescribes that "mothers shall suckle their children for two whole years." In ancient Egypt, nursing was commonly continued for three years, and in biblical Israel for two years. In Babylonia, the mother goddess Ishtar was often depicted nursing her baby. A Spartan royal law of the fourth century B. C. required mothers to breast-feed their babies, and Caesar ridiculed Roman mothers who retained nurses for their children.

The Merits of Breast Milk. Human milk is in many ways the perfect food. It is healthful; it meets most of the metabolic needs of the baby; it contributes to good growth; it is clean, thus lowering the risk of intestinal illness and general infection. Furthermore, it provides a host of protective factors. Breast-fed babies are more resistant to malaria and to infection caused by bacteria or viruses; and they are less likely to suffer from rickets and iron-deficiency anaemia. Breast milk, unlike many substitute foods, is easily digestible. Also, the baby is generally receptive. Breast milk is readily available and requires no preparation of any kind. Moreover, the quantity of breast milk for the infant's first half year is relatively satisfactory, even though the mother's diet may be inadequate.

Although nursing makes physiological demands on the mother with an inadequate diet, breast feeding is in some ways beneficial to the health of the mother. The nursing woman, because she does not usually menstruate, conserves her iron stores--an important consideration in poor countries where many women are anemic. Breast feeding is pleasurable, offering the mother the contentment of contributing very immediately to her baby's well-being. Of course, it greatly reduces the cost of child rearing.

The Decline. The current trend away from extended nursing in most of the poorer countries apparently has been strongly influenced by the wealthier ones. A continuing nationwide study of 2.5 million babies in the United States found that the number of mothers who were breast feeding at the time they left the maternity hospital had declined by nearly half in only ten years; the national average, which had dropped from 38 percent to 21 percent from 1946 to 1956, slid again to 18 percent in the following decade. The decline is most pronounced in the poorest states. Recently there has been a resurgence of interest in

breast feeding in the United States, but it has been concentrated among the college-trained and well-to-do. Declines in breast feeding similar to that in the United States have been noted in Great Britain, Australia, Sweden, and Poland.

The stigma against nursing, with its unfortunate consequences, is one of the values unwittingly communicated to the less industrialized world. In developing countries, artificial feeding--fashionable at first only among mothers of higher income with an awareness of hygienic needs--has penetrated to middle and even lower income families, especially in urban settings with their fully developed advertising and other communications and their premium on sophistication. A 1970 Brazilian study of 879 public maternity centers reported that after their first day, only 44 percent of the babies were fully breast-fed. In urbanized southeast Asia, it was not unusual for mothers-to-be to arrive at the hospital carrying canned formula.

What are the causes for the dramatic decline in breast feeding? Encroaching urbanization and modernization and new social values are significant influences. Breast feeding is often viewed as an old-fashioned or backward custom, and by some, as a vulgar peasant practice. Indeed, anthropologists, struck by the relationship of artificial feeding to societal change, have used the duration of nursing as an inverse measure of acculturation for some countries. In most developing countries, the greater the sophistication, the worse the lactation: the bottle has become a status symbol.

Failure of lactation in mothers is one of the responses to the stress of modernization. Among the tensions in a changing environment is the mother's anxiety about her capacity to breast feed. Her failure to initiate or to continue breast feeding is rarely traced to a physical cause but often to psychophysiological causes that interfere with the key "let-down reflex". In a study of Indian women, for example, over 80 percent of the highly educated in the highest socioeconomic group were unable to breast-feed their infants for as long as six months, whereas among the lowest socioeconomic classes, failure to breast-feed the infants for at least six months "was practically unknown." Social and cultural factors and their psychological and emotional accompaniments were far more important determinants of lactation performance than dietary and nutritional factors.

Changing social attitudes regarding the body reinforce the trend. Some women fear that breast feeding will ruin the shape of their breasts, a crucial concern in the increasing number of societies that emphasize their role in sexual attractiveness. Nursing in public, a common sight a decade ago in many parts of the developing world, is rapidly disappearing as the modesty accompanying the changes in attitude grows. Convenience also is a factor in the abandonment of

breast feeding. Women no longer bound by tradition, and now enabled by the changing pattern of home life to take advantage of an increasing number of diversions, have turned to artificial feeding to free themselves from the constraints of motherhood. This is especially true of those who wish to join the organized work force, although they are only a small part of the women who have abandoned breast feeding. Only 15 percent of the nonnursers in the West Indies and 10 percent of those in Singapore are employed (in jobs recorded in labor statistics; others, of course, work at odd jobs).

For many women, improved communication has brought knowledge of the alternatives to breast feeding. A leading Latin American nutritionist reports an immediate decrease in breast feeding as the unsophisticated Chilean mother learns of the existence of infant formulas via alluring advertising claims. In the West Indies, competitive representatives of baby food manufacturers visit the homes of new mothers and give free product samples. And in Nigeria, women from commercial firms make the rounds of maternity clinics, distributing free samples. The easy availability of free skim milk through institutional feeding programs also has been blamed for the wholesale defections from breast feeding. Distribution of free powdered milk--including that sponsored by the National Health Service--has been partly responsible for the radical decline of breast feeding among Chilean mothers.

A Conservation Policy

Concern over the effects of malnutrition with the decline of breast feeding has received virtually no attention from national planners. Given societal sensitivities and the highly personal nature of the subject, is it possible to intervene to reverse this trend? The potential for success of any organized effort is by no means clear. Yet, even modest improvements--an increase by a few percentage points of the proportion of mothers who elect to breast-feed, or extension of nursing by a few weeks or months for those who already do--could be translated into millions of dollars, and more importantly, probably millions of lives.

The idea of a government campaign to encourage maternal nursing is not new. The high infant mortality related to an eighteenth century vogue against breast feeding led the French government to print posters encouraging mothers to nurse. Finland reportedly went further; by royal proclamation, penalties were assessed on nonnursing mothers whose children died in the first six months of their lives. In the mid-1960's, the government of Uganda made a conscious effort to convince mothers that breast feeding is not a backward custom. And in the United States, sixteen years after it was formed in 1956, the La Leche League had 1,220 groups promoting maternal nursing. To design a single campaign that would be applicable to the many and diverse cultures in developing

countries would be impossible. Yet, recognizing the inherent difficulties, the costs and potential obstacles of such a campaign may be less imposing than those of alternate nutrition intervention programs designed to achieve the same ends.

The most essential objective of a campaign to counter the current trend is improved understanding of the benefits of breast feeding and of the dangers of forgoing it. Linked with this should be an effort to encourage added caloric intake for the mother during the nursing period and adequate food supplements to the child in the second six months of life. The stark facts about illness and death among non-breast fed babies in low-income countries must be convincingly communicated. Where feasible, the message that human milk is a safe, ready-made, simple, and inexpensive form of nutrition should be carried via mass media, because of their apparent effectiveness in changing food habits. The same advertising techniques that partly are responsible for the increase in artificial feeding can be used to counter the trend.

Even in societies liberated from tradition, some will be uneasy about attracting public attention to breast feeding. Here, family planning is an encouraging forerunner. Not too long ago, contraception was a subject fit for discussion primarily in medical circles, but today its discussion (if not its practice) has become widespread. India has begun to create awareness of the need for breast feeding: in 1970 a photograph of a mother nursing her child appeared in a four-column advertisement in a number of national periodicals. Although care was taken to insure that the picture would be inoffensive, criticism was anticipated. None materialized. Posters declaring "Breast Feeding is Best for Baby" also have had wide distribution in Zambia and in South Africa. In countries where cultural inhibitions about breast feeding rule out the use of billboards or other media designed to reach the general public, efforts should be made to direct the campaign selectively to the easily identifiable audience of young mothers-to-be. Magazines and daytime radio women's programs can serve as channels. A package containing special women's products can carry the message, and health clinics and maternity hospitals can easily reach women at the critical time. Home science classes for girls are among the opportunities the school system offers.

In creating awareness, the objective must be not only to remove the stigma of backwardness associated with nursing, but to defuse the sexual association. Perhaps there is no better technique to achieve these ends than the testimonial by cinema stars and other public figures. Experience in Israel and the Soviet Union demonstrates that, with proper societal attitudes, the decline in breast feeding need not be an inevitable consequence of urbanization.

A more forceful step toward halting the undesirable trend away from breast feeding is governmental action to control the advertising that might best be described as "antinutrition education." At a minimum, advertisers should be required to abandon the misleading claims of some patented baby foods, both explicit and implicit, like the Latin American advertisement for corn starch that, making no overt claims to being a baby food, nevertheless prominently features the picture of a robust infant. But even honest advertising presents problems. Advertising means revenue for the media and sales to the manufacturers; their firms are large and their markets extensive, and they are not without their influence on government. If political realities make regulatory action impossible, informal pressures should be applied to make food companies aware of the harm their products can do and to encourage voluntary compliance to some standards.

Governments can encourage breast feeding by making it more convenient. In urban areas where privacy is virtually nonexistent, inexpensive facilities can be provided. Just as governments build bus stands and public restrooms, so might they provide small structures in crowded downtown areas for nursing mothers; special rooms for nursing could be set aside in factories and other places of employment. Mothers who breast-feed might be given incentives. In the Soviet Union, a four-month maternity leave is granted to make sure that the mother establishes a breast-feeding routine before she returns to work; when she does return, the baby is put in a nursery at the place of employment, and every three hours the mother is given a nursing break. In Switzerland, monetary incentives are provided to mothers who nurse their children at least ten weeks.

It is the responsibility of those who plan free milk programs to recognize the problems they may raise. Such activities--especially the distribution of dry skim milk, which often is directed to the infant--must not be allowed to act as a disincentive to breast feeding. The Chilean government during the last ten years has increased twelvefold the free milk available for infants, but the decline in breast feeding has been even greater and, perhaps relatedly, the infant mortality rate in urban areas has increased.

Obstetricians, pediatricians, general practitioners, midwives, medical students, nurses, auxiliaries, and other government health workers should be indoctrinated in the importance of breast feeding and breast-feeding methods. Medical education generally gives little attention to nursing and often emphasizes the importance of artificial feeding. Of the sixteen hundred pages in the major U.S. textbook on pediatrics, only one and a half concern breast feeding, with no mention of the "let-down reflex." The indifference of the medical profession is at least partly responsible for the decline in breast feeding. Health workers must be educated to the importance of breast feeding and, both before and immediately after birth, make every effort to counsel new mothers accordingly.

Finally, efforts must be undertaken to prevent lactation failure, which has become increasingly common under stress of modernization. A program should include information not only on the "why" of breast feeding, but also its "how". Where breast feeding is widely practiced, the effort should be to preserve the practice while not calling undue attention to the techniques. In a traditional society with an accepting, matter-of-fact attitude toward the ability to nurse, lessons that raise questions could be confusing and cause anxieties that could be counterproductive.

In sum, the dramatic decline in breast feeding in the low-income countries, especially in rapidly growing urban areas, means a staggering loss in one of the primary determinants of nutritional status. The cost is substantial, both in high mortality and morbidity rates and in outright economic loss. Moreover, fertility rates are also affected, since breast feeding probably has prevented more conceptions than all other forms of contraception. But steps can be taken, and the size and implications of the problem should be examined and techniques be carefully designed to deal with it. For the vulnerable infant and young child, an effective public effort to counter the current trend may be of greater significance than any other form of nutrition intervention.

[Extracted from Chapter 7 of
The Nutrition Factor, pp. 89-106.
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Institution, Washington, D. C.,
1973.]

A. I. D. PROGRAMS FOR COMBATTING MALNUTRITION

Martin J. Forman

During the past few years nutrition has been assuming a larger role in A. I. D., as in the U. N., the World Bank, and in other bilateral aid programs. This reflects a growing view that: (a) improving nutritional status is an important component of any effort to improve quality of life, especially for the poor; and (b) malnutrition affects the development of a nation's human capital potential, and therefore has serious development implications in many areas. Previously nutrition had more typically been seen by governments and aid donors alike as a somewhat specialized activity, featuring feeding programs for special groups such as school children and disaster victims, along with the development of new protein-rich foods or food supplements, and related survey, training and research efforts. This is what nutrition specialists were expected to do; while in a separate department agricultural specialists endeavored to increase farm production with little concern for consumption effects, and in other departments different specialists were concerned with employment generation and income distribution, with public finance and trade, etc. The existence of malnutrition was, of course, widely recognized and deplored. The difference is that today it is coming closer to the center of developmental concern and action.

Nutrition and Planning

The keystone of A. I. D.'s nutrition effort is to encourage and assist developing countries to incorporate nutrition goals into their national, regional, and local planning processes to ensure that the subject gets attention at an appropriately high level of government decision making. A. I. D. began working on nutrition analysis and planning at the beginning of this decade. We became more confident of the correctness of our approach when the November 1974 World Food Conference produced a consensus resolution urging all countries to develop food and nutrition policies and plans [see discussion of Resolution V in the World Food Council article above].

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During the past five to ten years, promising new technologies and planning methods have been evolving which offer promise for achieving a significant impact on malnutrition. For example, A. I. D. has developed a methodology which employs a systems approach to problem analysis, determination of causes, and intervention selection based on cost-effectiveness and feasibility. Methodologies have also been developed for conducting nutrition assessments and food consumption surveys in a way that is rapid, relatively inexpensive, and within the capability of most developing countries. In the past three years, new techniques have been used to carry out surveys in Nepal, Lesotho, Liberia, Sierra Leone, Sri Lanka, and Togo, and others will get under way shortly in Egypt and Cameroon. We have also developed and tested techniques to evaluate child feeding and nutrition education programs, and are working on methods to evaluate other forms of intervention as well as overall nutrition programs. Such techniques are needed to enable policy makers to make intelligent nutrition investment decisions. Further, a project is now underway to develop a methodology for a systematic approach to malnutrition at the local community level.

Today countries have indeed begun to systematically analyze their nutrition problems, and this has revealed what needed to be done; it also clearly indicated that a greater magnitude of effort was needed. This has led to higher local budget allocations and a need for increased levels of aid. Inter-sectoral country programs have been undertaken, assisted by A. I. D., in the Philippines, Thailand, Pakistan, Zaire, Colombia, Chile, Costa Rica, Honduras, Bolivia, and the Dominican Republic. Inter-sectoral programs involving analysis and planning are at various stages of development in a number of other countries, including Morocco, Tunisia, Bangladesh, Nicaragua, Jamaica, and Haiti. In addition, Brazil and Indonesia, assisted by the World Bank, have reached the point of treating nutrition as part of their inter-sectoral development planning.

Other Nutrition-Related Activities

Agriculture. While the greatest concentration of A. I. D.'s effort in agriculture is on the goal of increasing food production, more and more attention is being given to the ways in which policies and programs affect the quality and quantity of food consumption by the poor. Agricultural sector analysis efforts help countries to predict the consumption effects of alternative investment decisions. Plant breeding efforts examine the relative merits of increasing yield or increasing the nutritive value of foods. A new project has just been launched to study the consumption effects of agricultural policies from past experience in order to provide insights needed to guide future actions.

The U. S. Food For Peace Program (PL-480). When this program began in the 1950s various untreated surplus commodities, mostly grains, were donated to support many kinds of programs. This has changed drastically. Today, most of the foods are fortified with vitamins and minerals, or consist of blends of cereals and legumes to enhance protein quality and quantity.

More than half of the 1.4 million tons of (Title II) food shipped annually now goes to pregnant and nursing women, and to children. On a regular basis, these foods are supplementing the diets of 26 million children with a portion of their daily nutrient requirements, providing for some the only adequate meal of the day. The timely availability of food in times of natural disasters continues to save lives.

Population and Health. It is only a little over ten years that the problem of burgeoning population growth began to receive anywhere near the kind of attention it deserves. Health programs -- which had been in decline for a number of years -- also began to accelerate around this time, as developing countries and donor agencies began to shift emphasis toward promoting social welfare as well as economic development. With these changes, there was a greater need to know more about the inter-relationships of health. nutrition and family planning. By lowering infant and child mortality, do nutrition grams work to contradict programs that aim to reduce rates of population growth? Do some oral contraceptives interfere with lactation, causing greater malnutrition through a reduction in infant breast feeding? If intestinal malabsorption is responsible in some countries for food losses of up to 20-25%, as some estimate, would it be more feasible and cost-effective to prevent some of the resultant malnutrition through environmental sanitation programs, rather than by trying to increase food availability? A number of studies currently under way seek answers to questions such as these.

In other cases, existing programs have a new emphasis or rationale. For example, the promotion of breast-feeding for the purpose of enhancing infant nutrition also serves to increase the period of infertility following childbirth and thus contributes to a better spacing of pregnancies. Educational programs, therefore, stress the desirability of prolonging the duration of breast-feeding, or more correctly, try to reverse the trend toward earlier weaning. Clean water supplies and efficient waste disposal systems are being sought by many urban communities for convenience and public health reasons, and are supported by A. I. D. in 19 countries. They also contribute to preventing malnutrition by reducing the incidence of intestinal disorders, which in turn prevents nutrient absorption and malnutrition.

These are a few of the inter-relationships and their program implications. There is also an inter-relationship in terms of delivery of services, since most nutrition and family planning programs and many health programs aim for the same target audience -- women of child-bearing age. The programs can be mutually re-enforcing and combining the delivery of various services can bring efficiencies of cost, can improve acceptability, especially of family planning, and can extend the reach of some services into areas where other programs already exist.

Vitamin A Deficiency. In early 1974, A. I. D. geared up to launch special efforts to combat Vitamin A deficiency. With the help of technologies de-

veloped at the Institute of Nutrition for Central America and Panama (INCAP), Guatemala and Costa Rica are now fortifying their sugar supplies with Vitamin A. In Haiti, El Salvador, Bangladesh, and Northeast Brazil, UNICEF, the Helen Keller International Foundation, and A. I. D. have assisted programs which distribute twice annually to children a single capsule containing a sufficiently large dose of Vitamin A to provide all of the child's needs for six months, thereby protecting it from the possibility of blindness caused by Vitamin A deficiency. In Indonesia, A. I. D. supports a massive five year program to introduce and test various approaches to delivering Vitamin A to vulnerables. In Pakistan, the technology has been refined for fortifying tea with Vitamin A.

Food technology. Many countries seek to improve the quality of their food supply through fortification, blending cereals and legumes, or developing new formulated foods. In the Philippines thousands of children are served daily with a baked wheat roll, fortified with soya, vitamins, and minerals, appropriately called a "Nutribun", using Food For Peace commodities. In Thailand, children are served a high protein textured vegetable product which approximates meat in appearance and nutritive value. In Pakistan, plans are under way to fortify atta, the wheat flour used in making chappattis. Bakeries in Korea and Ecuador are testing the feasibility of marketing a soy fortified bread. In Brazil, A. I. D. helped develop a technology for fortifying cassava with soy grits; and in Chile, a new blended dry beverage is being produced for reconstitution into a drink for free distribution to young children. The product is equal in nutritive value to milk, very acceptable to the local taste, and is much cheaper than the milk which had been largely imported

Motivation. To help change food-related behavior, modern advertising techniques are being explored for the mass media, especially radio. Rather than selling branded products, advertising methods can be used to "sell" breast feeding, sanitary practices, etc. Successful test campaigns have been conducted in Ecuador, Nicaragua, and the Philippines, and similar campaigns are being readied in Bolivia, the Dominican Republic, and other countries.

In sum, the changes in concept and approach described above incorporate nutrition into development planning, and offer new hope that the problem will no longer be ignored.

[An original article]

Book Review

Food First: Beyond the Myth of Scarcity, - Two View
by Frances Moore Lappe and Joseph Collins
with Cary Fowler; Houghton Mifflin Co.,
Boston, 1977, 466 pp. $10.95.

1. F. James Levinson is a nutritionist with the U.S. AID Mission in Dacca, Bangladesh.

Some of the most powerful, perceptive and revealing writing about a field is often done, not unexpectedly, by those largely outside its establishment. In their new, popularly-written book, Food First, authors Frances Moore Lappe and Joseph Collins lay solid claim to share in this distinction. Lappe is best known as the author of Diet for a Small Planet, which probably sold more copies than the combined total of all nutrition textbooks.

Food First begins with the assertion that every country in the world has the capacity to feed itself, but that simply increasing agricultural production will not eliminate hunger. Is the problem one of distribution--and farm to market roads, storage depots, feeding programs, and remote villages? Wrong, say Lappe and Collins; "Food distribution only reflects the more fundamental issue of who controls and who participates in the production process."

The picture they paint of this process is disturbing. The advantages of agricultural "modernization" go primarily to larger landholders who are "credit-worthy", who benefit most from government price policies, and who can afford the irrigation and fertilizer on which new seed varieties are dependent. As production becomes more profitable, one finds a whole new class of farm owners: money lenders, military and government officials, and city-based speculators. There is increasing farm mechanization, and a rapidly growing tendency to use the best land for more profitable cash crops. (In Colombia, one hectare planted with wheat or corn yields roughly 12,500 pesos a year. The same hectare planted with carnations would yield 1 million pesos). The poor, meanwhile, are displaced as tenants (it's more profitable for landowners to mechanize and farm the land themselves), and subsistence food grain production is shifted to marginal lands which increases food prices and, at the same time, exacerbates

soil erosion.

To make matters worse, the larger landholdings actually produce less food per unit of land than small holdings. A World Bank study of six Latin American countries shows the value of output on small farms from three to fourteen times higher per acre than that of large farms. Where national food supply does expand, the increases go primarily for middle and upper income group consumption, to feed livestock, or to exports. With this "inefficiency of inequality", the authors ask, are we really approaching "natural limits" in food availability? Or can means be found to change a system which creates shortages and which, in the process, compounds the deprivation of the poor? The International Labor Organization notes sadly that the rural poor in the seven South Asian countries (comprising 70 percent of the rural population of the non-Communist underdeveloped world) are worse off than before, and notes that "the increase in poverty has been associated not with a fall but with a rise in cereal production per head..." Being cut out of production means being cut out of consumption.

In a highly readable question and answer format, Lappe and Collins address a host of related questions including major sections on agricultural trade (the "global supermarket"), "food power", multinational corporations and international agencies. Some may ask what all of this has to do with nutrition. The answer is, of course, that any national policies will affect consumption or nutritional well being when they affect the incomes of the poor and the food prices they pay. This means that policies governing agricultural production, land use, prices and trade often dwarf, in their nutritional impact, the effects of explicitly labeled nutrition policies. We nutritionists should never allow ourselves to think that these issues aren't our concern.

There are problems with the advocacy stance of Food First. Perhaps the most serious of these is the penchant of the authors to paint governments and assistance agencies as conspiring monoliths with malicious intent, rather than as having within them a wide range of opinion and outlook. Institutions once thus labelled can do no right. If they try land reform they are accused of diffusing the peasant movement. A program of subsidized food consumption is seen as a ploy to keep prices down and diffuse discontent with authoritative regimes. The problem, of course, is that such unbalanced interpretation and use of selective evidence can have the effect of becoming self-fulfilling prophecy. Rather than strengthening the hands of those people in institutions who are working for constructive change, the institutions themselves cease to be taken seriously.

There are also problems of generalization. The international trade chapters relate far more to Latin America and Africa than they do to South Asia. The often romanticized discussion of precolonial periods ignores the considerable exploitation which existed even then. The discussion of decentralized decision making makes no mention of the difficulties

in circumventing the problems of class and local ruling elites. But these are minor problems in a book which succeeds so effectively in exposing the traditional myths about world food. It is destined to have a considerable impact on public thinking on this subject in the years to come.

The real contribution of Food First is not with its answers - they will take many years to evolve for the large majority of low income and industrialized countries with centrist political ideologies. Rather it is in asking the critical questions, and in a manner which assures that they be taken seriously. The frankness with which the authors discuss their own struggles and self doubt is in fact likely to generate empathy among countless numbers of concerned persons around the world who have been frustrated in their attempts to get a handle on the hunger issue. I found myself at times wincing and swallowing hard, and at other times angrily shaking my head. But I never found myself doubting the power of Food First, or that much of its message is essentially right.

2. Dana G. Dalrymple is an agricultural economist with the U.S. Department of Agriculture, on detail to AID.

Jim Levinson, a friend and colleague with whom I usually agree, has prepared a far too complimentary review of Food First. The book has a certain charm, particularly for one as concerned with nutrition as Levinson is, and I am afraid he has fallen prey to some of it. I agree with many of the ideas presented in the book, particularly the idea that every country in the world could feed its people better, but I also think it has many deficiencies which are not discussed in Levinson's review.

The book is almost entirely devoted to "debunking myths," some of which are straw dummies or exaggerated. It is a long chain of horror stories. So much emphasis is placed on negative factors and their removal that it is not clear what positive steps should be taken; such thoughts are confined to a rather small and fuzzy section at the end of the book. The authors' admiration for the way the food situation is handled in Cuba and China is evident, particularly in the last section. It is also clear that they view the food problem as social rather than technical. What the authors seem to mean is that a structural reordering of society is necessary, and perhaps the rest will follow - a rather simplistic philosophy. Moreover, the author's approach is partial, selective, anecdotal, and evangelical. Where they do make a good point, it is often overdone, or undone by some subsequent bit of zealousness. There are at least two sides to most questions; the authors spend little time or effort looking for or presenting any other side.

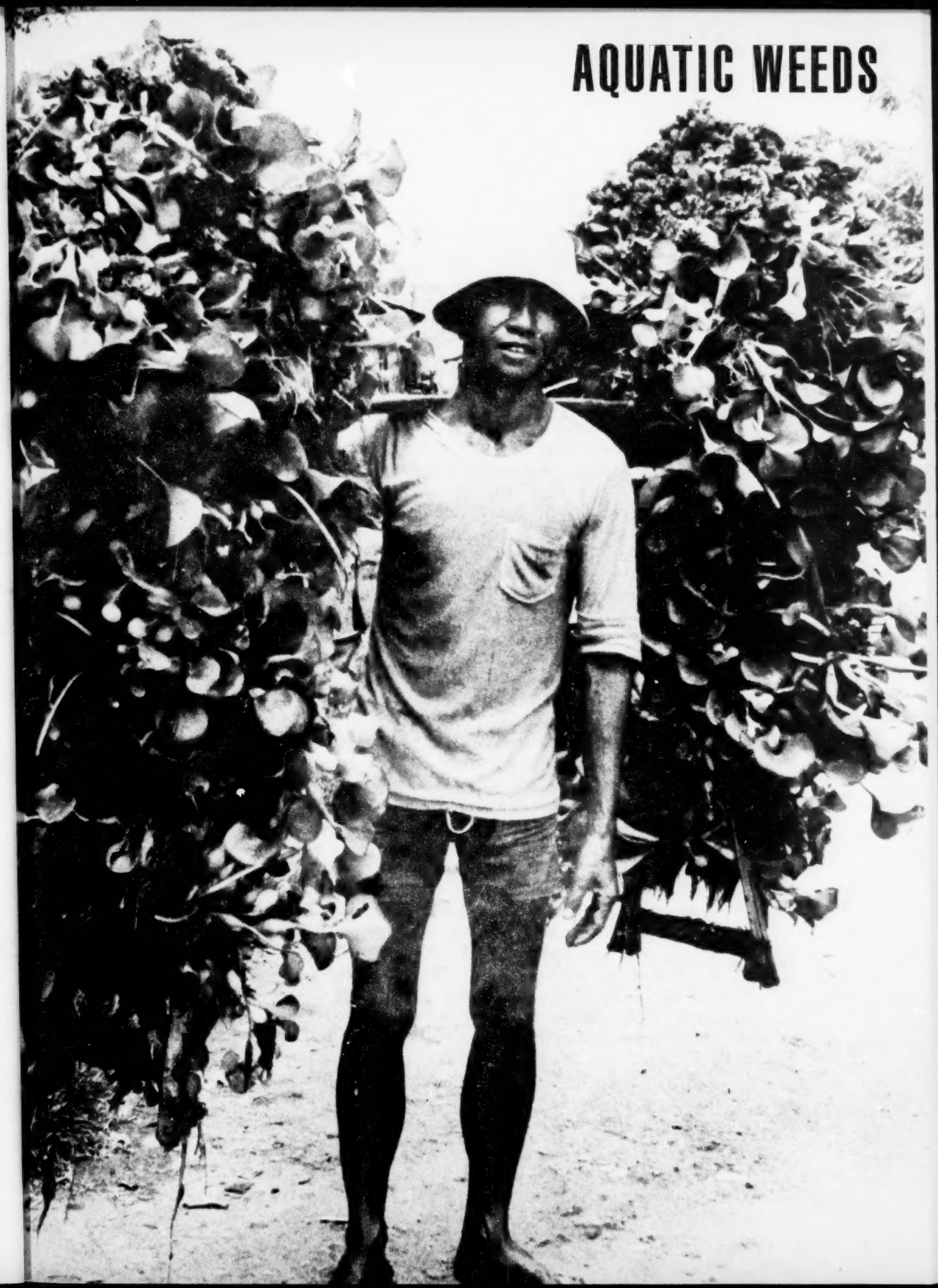
The overall food situation in a country will generally be improved only if the food supply is expanded, the products made available at lower cost, and individual purchasing power of the poor and malnourished is increased. The food supply can be expanded by increasing production or increasing imports; current thinking generally favors increased local production of foods consumed by the mass of the population. If the expanded supply is to be available at lower cost to consumers and farmers are not to be disadvantaged in the process, less costly means of production and marketing must be found. Technological change is a major way of reducing production and marketing costs per unit of product. At the same time, it would be desirable to increase the effective demand of society for food. This is most readily done by increasing consumer incomes, particularly among low-income consumers, which involves many economic and social considerations beyond agriculture. It is a complex business, and it will not be simply solved by revolutionary social changes.

In this sense, the authors substitute new myths for the old ones they debunk. While I agree with some of the debunking, I think they get too wrapped up in it and begin to believe that nothing is possible through traditional channels. They lose perspective and forget what the general situation is. They focus on the extreme rather than the typical, the latter being duller and less convenient to their theme. For example, I find their treatment of the Green Revolution extremely biased and limited; their theme is to show that no improvements are possible through technological means. This is, of course, absurd. The way to solving the food problem is not to be found solely through either technological or social changes. Both must be involved, in a synergistic relationship. Just as some people focus too exclusively on the technological end, the authors have gone much too far the other way. Bringing these two groups of zealots together into a more productive and realistic alliance may prove difficult.

All this may be a more negative reaction than some other reviewers will provide. I found myself enjoying some of the book's "cartoons" or caricatures of traditional practices, but I didn't take many of them too seriously because I think I know enough to realize that the whole story has not been told. Some people will be misled by this book; but if it serves as a counterweight to the more ridiculous statements on the other side, perhaps some good will also be done.

[Reviews extracted from the "In Print" section of two issues of War on Hunger, August and December 1977. Published by the U. S. Agency for International Development, Washington, DC.]

AQUATIC WEEDS



INDONESIAN CARRIES HARVESTED WATER HYACINTH TO A NEARBY PIG FARM FOR PIG FEED. ONE ANIMAL MAY CONSUME 1.5 TO 2 KG OF FRESH PLANTS PER DAY. (PHOTO: M. SOERJANI)

Making Aquatic Weeds Useful

National Academy of Sciences
Washington, D. C.

[The problem of water plants growing in canals and ponds and interfering with irrigation, drainage, hydroelectric power, etc. has become serious in a number of places. This article discusses means of reducing these weeds and at the same time using them as economic assets in a number of ways.]

The menace of water weeds is reaching alarming proportions in many parts of the world. Water is an important resource, and aquatic weeds affect it adversely by blocking canals and pumps in irrigation projects; interfering with hydroelectricity production; wasting water in evapotranspiration; hindering boat traffic; increasing waterborne disease; interfering with fishing and fish culture; and clogging rivers and canals so that drainage is impossible and floods result.

This is a global problem, but it is particularly severe in tropical nations where warm water and increasing numbers of dams and irrigation projects foster aquatic plant growth. Furthermore, the problem is worsened by increasing enrichment of natural waters by fertilizer runoff and by nutrients from human and agricultural wastes. In India, large irrigation projects have been rendered useless by plants that block canals, reducing water flow by as much as four-fifths. Subsistence farmers in the wet lowlands of Bangladesh annually face disaster when rafts of water hyacinth, weighing up to 300 tons per hectare, are floated over their rice paddies by floodwaters; as the floods recede, the weeds remain on the germinating rice, killing it. Panama Canal engineers have estimated that the canal would be impassable within three years without continuous aquatic weed control measures. As aquatic weeds spread,

they disperse the water snails that cause schistosomiasis, a debilitating disease prevalent in many developing nations. These snails live on the dangling roots of floating plants and ride along as wind and current float the plants around. In addition, aquatic plants foster malaria, encephalitis, and other mosquito-borne diseases because small, sheltered pools perfect for mosquito breeding are formed between the floating plants.

As the serious negative implications of the presence of aquatic weeds are becoming more widely recognized, scientists, engineers, and government administrators are beginning to take action. Unfortunately there is no simple way to reduce the infestations. Herbicides that kill aquatic weeds and mechanical devices that harvest them are the only methods used in the developed countries. Both are expensive, and many developing countries must spend scarce foreign exchange to import them. Even when they do, chemical and mechanical methods often prove almost impossible to use because of difficulties of equipment maintenance and of access to remote or swampy areas. Chemicals may also adversely affect the environment.

At the same time, however, aquatic weeds constitute a free crop of great potential value--a highly productive crop that requires no tillage, fertilizer, seed, or cultivation. Aquatic plants have potential for exploitation as animal feed, human food, soil additives, fuel production, and wastewater treatment. This report explores some alternative ways in which aquatic weeds can be controlled and made useful. Part I examines the uses of various fish and animals which feed on the weeds. Part II describes the processes needed to harvest and transform these weeds into useful products, and Part III considers other uses of such weeds.

The aquatic weeds discussed here are generally classified as floating, submerged, or emergent. The plants most widely recognized by the public as weeds are the floating types, such as water hyacinth (Eichhornia crassipes), water lettuce (Pistia stratiotes), and salvinia (Salvinia spp.). The roots of these plants hang in the water and are not attached to the soil. Weeds that grow below the water surface are called submerged. Often they form a dense wall of vegetation from the bottom to the water surface. Many submerged weeds are known, but hydrilla (Hydrilla verticillata) and water milfoil (Myriophyllum spicatum) are two of the most notorious. Rooted weeds that extend above the water surface are termed emergent. Cattails (Typha spp.), papyrus (Cyperus papyrus), the bulrush (Scirpus species), and the reed (Phragmites communis) are this type.

Aquatic weeds are often more productive than terrestrial plants. Water hyacinth, for example, is one of the most prolific plants on earth. In one experiment, two parent plants produced 30 offspring after 23 days

and 1,200 at the end of four months. Stands of 470 tons of water hyacinth per hectare, and weight gains of 4.8 percent per day have been measured. When grown on sewage effluent, the water hyacinth's productivity can become enormous: growth rates of the order of 800 kg of dry matter per hectare per day have been recorded.

The composition of aquatic weeds is dominated by a huge preponderance of water; the dry-matter content is very low, generally from 5-15 percent. By comparison, terrestrial forages contain 10-30 percent solids. The low level of dry matter has been the major deterrent to the commercial use of harvested aquatic weeds. In order to obtain one ton of dry matter, 10 tons of most aquatic weeds must be harvested and processed; for the water hyacinth, which is usually only 5 percent dry matter, 20 tons must be harvested and processed just to get one ton of dry matter.

Aquatic weeds are generally between 10 and 26 percent crude protein (on a dry-matter basis)--a range similar to that found in terrestrial plants. In water hyacinth, water lettuce, and hydrilla, at least 80 percent of the total nitrogen is in the form of protein. Sand, silt, and encrusted insoluble carbonates from the water often account for much of the mineral content. Although silt can be washed off the plants, in practice it represents part of the chemical composition of the harvest. The amount of minerals varies from 8 to 60 percent of the harvest (dry weight), depending on the waterway's chemical content and turbidity. The amounts of phosphorus, magnesium, sodium, sulfur, manganese, copper, and zinc in aquatic weeds growing in nature are generally quite similar to those in terrestrial plants. However, aquatic plants are often richer in iron, calcium, and potassium than land forages, and some species are known to concentrate such minerals to very high levels. Pesticides have been found in aquatic plant samples collected when the waterway had been recently treated with herbicides or insecticides. No evidence of toxicity to mice, sheep, or cattle has yet been found in water hyacinth or hydrilla samples. Nevertheless, an aquatic weed's composition mirrors the chemical composition of its waterway: If mining, industry, or natural rock formations add toxic minerals to the water, the weeds downstream can be toxic, even though the same species upstream are not.

I. Uses of Herbivorous Fish and Animals

The Chinese grass carp (Ctenopharyngodon idella Val.) is a fast growing fish that feeds voraciously on many aquatic plants and grows to weigh as much as 32 kg. In several countries it is now being tested for aquatic weed control. It has proven to be an exceptionally effective control agent for submerged weeds in some parts of the United States. For example, in 1970, when grass carp were first introduced,

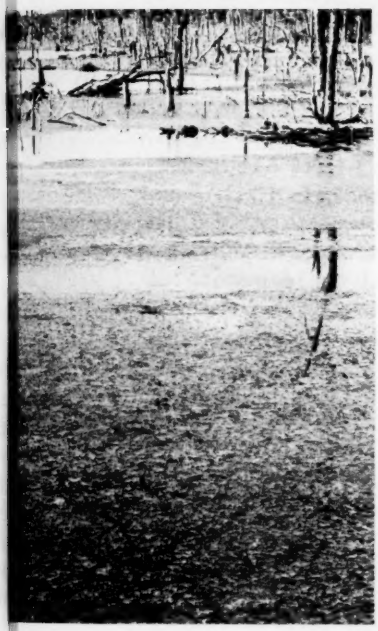
an estimated 20,000 ha of public lakes contained submerged weeds in the state of Arkansas; in 1975, the state government determined that no infestations of problem magnitude remained in these waters. The grass carp converts aquatic weeds to valuable food. Already commercial fishermen in Arkansas are beginning to market the grass carp; it has gained instant acceptance there and is now recognized as a tasty and nutritious commercial fish. On a dry weight basis, they are approximately 80 percent crude protein (18 percent on a wet weight basis). The flesh is white, firm, flaky, and not oily.

The grass carp feeds primarily upon submerged plants but will also eat such small floating plants as duckweed. Overhanging terrestrial plants and bank grasses may be consumed when preferred plants are not available, but they are unlikely to eat many water hyacinth or other floating weeds. The grass carp's teeth are located in its throat and, to feed, it must get the plant material to them. Active feeding begins when water temperatures rise above 10° C with an optimum feeding temperature of near 26° C. Grass carp grow fast. Under optimum conditions they may attain an edible size (1 kg) in one year; thereafter, growth increases of 2-3 kg per year in temperate zones and up to 4.5 kg per year in tropical regions can be attained. Weight increases up to 6 g per day have been measured for grass carp feeding on hydrilla in Florida. With this rapid growth, grass carp quickly consume stands of aquatic weeds. Small fish, less than 1.2 kg, may eat several times their body weight of plant material daily while large fish consume their body weight daily. (In the absence of aquatic weeds, grass carp can be fed on terrestrial plants; in Malaysia it is common practice in the intensive culture of grass carp to feed them napier grass.)

Weed control is rapidly achieved if more than 75 fish per hectare are present. Lower stocking rates reduce the rate of weed control, but result in larger, more valuable food fish. Quite apart from weed control, the grass carp can be cultured for food. Yields of 164 kg of fish per hectare in temperate zones and 1,500 kg per hectare in tropical weed-infested waters have been obtained. This is usually done in polyculture in which several different fish species are grown together, each living off a different food in the pond. Grass carp may be harvested from lakes or streams using gil nets, trammel nets, hoop nets, and seines. They are very agile and frequently leap over capture nets. They can also be caught with fish traps or hooks baited with vegetation.

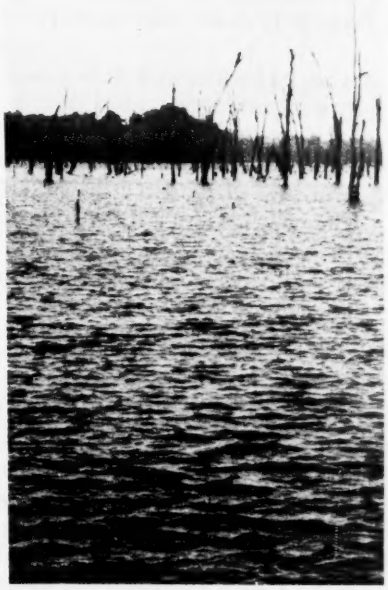
When introduced into a new country, grass carp should be initially maintained in quarantine, and only released when known to be free of serious pest parasites and diseases. They should also be tested to determine any adverse effects they might have on native aquatic animal life. During the first few weeks after hatching, grass carp are not herbivorous. They eat zooplankton and other microscopic animals. It is not until the fry become fingerlings that they begin feeding on filamentous algae and small stems of tender plants. In some parts of the United

LEFT: Zambia: when the lake behind Kariba Dam filled in 1960, the water fern, Salvinia molesta expanded explosively. By 1962 it covered some 1,000 km^2, a fifth of the area in one of the world's largest man-made lakes. (Photo: Stan Tucker)



LEFT: Lake in Arkansas, USA, filled with weeds Ceratophyllum demersum) when grass carp were added in 1971...

RIGHT: Three years later the same lake is weed free. (Photos: W. M. Bailey)



LEFT: A Manatee: Tropical marine mammal, about half a ton in weight and 3 m long when grown, and a voracious weed eater.

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States and other countries, it has been argued that the fry might eat the eggs or fry of native or sport fish, such as trout and bass, and reduce their populations. As of late 1975, however, there was little evidence that this occurs. [Fry are "baby" fish; fingerlings are "small children."]

In most waterways outside its native China the grass carp has failed to spawn naturally; however, it did spawn at least once after introduction into several rivers in the USSR, Japan and Mexico. Until recently, in fact, researchers reported difficulty in spawning the grass carp artificially. Now, however, the techniques have been developed and, at least in Arkansas where several million fry are produced each year, artificial spawning is routine. Grass carp fingerlings must be carefully protected during rearing since they are vulnerable to predators and heavy losses can occur.

In the past decade the grass carp has been introduced into a score or more countries, and there is now much experience and knowledge to be shared among the researchers involved. The fact that natural reproduction is not common in tropical regions may indicate that the fish needs a distinct change in seasonal temperature to initiate spawning. Research on this and other factors that control grass carp reproduction is urgently needed. The grass carp's practical yield potential is still unknown, and research is needed to determine stocking rates and disease and predator control, as well as the plant species and environments that raise its growth and productivity to a maximum.

Tilapia. Tropical lowland fish common in Africa and the Middle East, tilapia have been important food sources for millennia. Some species prefer higher plants, some filamentous algae, some plankton, while others consume various aquatic fauna. Several species are voracious feeders and are used to control weeds. Tilapia are prolific and hardy, and can be cultured in stagnant ditches and pits fatal to other useful fish. They are cheap and easy to breed, grow rapidly, and their flesh is much valued as food. With little help, African and Asian peasant farmers have quickly learned to culture them in small-scale subsistence and commercial enterprises. There are few comparable herbivores among the world's fish.

Tilapia are essentially tropical fish, but they can live under a wide variety of conditions. Many species are little researched and almost nothing is known of their potential for utilizing aquatic weeds. Some of them may give better results than the species that have been spread widely through the tropics. Because different species of tilapia will mate and produce hybrids, the fish may eventually be bred for desirable characteristics. Many tilapia consume the larvae of midges and mosquitoes, both of which spread disease to man, and they reduce the niches between plants that protect the larvae from other predators.

Tilapia have limitations, however; they breed so prolifically that a waterway becomes overpopulated; stunted fish, too small for eating, result. Techniques for keeping tilapia populations in balance are known but require skill to use successfully. Currently, the most effective method is to add a predatory fish to the waterway. This then preys on the young tilapia and, if edible, can be useful itself. Another population control technique is based on the tilapia's unusual genetics. Crosses between species surprisingly can produce hybrids of one sex only; at least three crosses using different species of tilapia have produced only male hybrids. These can, of course, be stocked without fear of reproducing. Much research remains to be done to test more crosses and the fecundity and feeding habits of the hybrids.

Silver Dollar Fish. The small, tropical, herbivorous, South American fish Metynnis roosevelti and Mylossoma argenteum (commonly referred to as "silver dollars") can control a variety of submerged aquatic weeds. They are aggressive eaters and, when traveling in schools, consume large quantities of submerged aquatic vegetation, including many pondweeds. Silver dollars are mowers; they frequently bite off the weeds at the base of the stem close to the roots. The mass of loose vegetation floats to the surface; there, the silver dollars usually graze it later or leave it to accumulate along the shoreline where it decays. Dense growths of vegetation are rapidly removed from ponds when the fish are stocked at rates of 1,200-2,500 fish per hectare. Little is known of their potential yield or value as food, except that they occur in large numbers and are sought after and relished by the people along the Amazon River. They grow to a length of 13 cm, and are related to and resemble the piranha (Serrasalmus spp.) - so much so that they are sometimes mistaken for this dread carnivore. Their bright silvery color and small scales enhance their attractiveness as food and as bait for other fish. Harvesting techniques are similar to those used to catch tilapia.

Silver dollars become active grazers in warm waters, 21-35° C. In temperate countries heated facilities are needed for over-wintering; temperatures less than 16° C are fatal. Considerable research is needed on silver dollars to identify the weeds they consume or shun; the techniques for spawning, culturing, and managing them; their value as food; and their sensitivity to adverse water quality.

Manatees. The manatee, or "sea cow", (Trichechus species) is indigenous to 40 tropical countries. A large, warm-blooded, air-breathing herbivore, it is a docile, retiring animal that has been suggested as a weed control agent for its tropical habitat in Central and South America, the Caribbean, and West and Central Africa. But the manatee is threatened by extinction. It cannot be removed from the wild and used for weed control; there are not enough individuals left. Conservation and research are badly needed to relieve the threat of extinction. If current populations can be preserved and restored, and

if successful husbandry and artificial breeding can be achieved, the sea cow might have wide use in the tropics as an aquatic counterpart of beef cattle, a herbivore that grazes underwater pastures and produces nutritious meat and valuable hides for man.

The manatee lives in both fresh and salt water. Strictly vegetarian, manatees prefer succulent submerged species but, if denied these and hungry enough, they will consume almost any type of water plant as well as many terrestrial grasses and leaves that come within reach. They may consume as much as a twentieth of their body weight each day. An adult manatee, exceeding half a ton and 3 m in length, possibly consumes 20 kg of wet vegetation each day. Manatees may live as long as 50 years. Though large, manatees tend to remain passive and immobile out of water and thus can be transported safely. They can survive in water that is fresh, brackish or saline, acid or alkaline, muddy or clear. More than 50 manatees have been introduced into Guyana's irrigation canals, reservoirs, and drainage systems for weed control. In some they have been very effective. For example, in the Georgetown Water and Sewage Works, two manatees (each 2 m long) were introduced in 1952 to a canal (7 m wide and 1,500 m long) with a massive growth of submerged weeds. In only 17 weeks they had cleared it completely. In the 24 years since then manatees have been used to keep this water (the city's municipal supply) weed-free.

Manatees are a potential source of protein if a reliable program of captive propagation with effective enforcement of laws protecting wild populations can some day be developed. Alternatively, restoration and careful management of wild populations could produce a harvestable surplus for protein and other purposes, such as weed control. They may be more appropriate for controlling weeds in canals rather than lakes or rivers--a confined waterway allows better control and protection.

At present, however, the number of manatees in some countries may be adequate for the animal to be used in small-scale local weed control programs, but it is on the international list of endangered species and protected in most countries where it exists. Nowhere are there populations large enough to support an export trade to nations that would like to introduce them. Hunting manatees as a source of meat is wasteful, undesirable, and irresponsible under conditions of today. The few wild populations known to exist are inadequate to support any significant harvest levels for this purpose; artificial propagation has not yet been achieved; and any inadvertent stimulation of a commercial market for manatee meat would drain the already depleted wild stocks disastrously.

Manatees rarely breed in captivity or semi-captivity. The reasons are unknown, but are perhaps related to a nutritional deficiency,

confinement-induced stress, or inadequate space in which to move about. In addition, they evidently have a slow reproductive rate and the gestation period may be about 13 months, while cow manatees probably breed no more than every 2 years. Comprehensive physiological and behavioral studies are needed to understand and accelerate the animal's breeding. Protecting the manatee may also prove unexpectedly difficult. They drown if trapped in nets and culverts, unable to surface to breathe air. Water temperature is important: below 18° C manatees may die from complications, including pneumonia, which restricts their use to truly tropical waters. Manatees require waterways at least 2 m deep (though they will enter shallower sections to feed). In navigable waterways they can be damaged or injured by barges or fatally wounded by boat propellers. As in Guyana, a manatee pond in a public place may be used to educate the public about the ecological significance and national importance of this gentle, friendly creature.

Crayfish. Lobsters command extraordinary prices and are the basis for large commercial fisheries and international trade. Lobsters live in the sea, but in most countries freshwater counterparts are common in streams and lakes. Most of these belong to the genera Orconectes, Procambarus, and Cambarus and are known as "crayfish," "crawfish," "freshwater lobster," etc. These animals are usually about 10-18 cm long but, like lobster, have large and edible tail muscles. Boiled in salt water, they are a delicacy. Frozen crayfish tails are becoming a valuable export from many countries including Turkey and the United States.

Crayfish are native to all continents except Africa and Antartica. Over 300 species are known. A few are exclusively herbivorous. Most crayfish are omnivorous scavengers, but readily become vegetarians if necessary. Some of the plants they eat can be noxious aquatic weeds. In general, however, crayfish should be thought of more as an available crop associated with aquatic weeds, not as a weed-control agent. Crayfish live in shallow waterways, and some are well-adapted to warm tropical conditions. They tolerate wide ranges of soil type and water temperature and quality.

The following description is largely based on Procambarus clarkii, the red crayfish that is widely farmed in Louisiana. The young grow rapidly and mature in 6 months, reaching a weight of 40-45 g. To grow the large specimens that bring the highest prices may take 8-14 months, however. In California and Louisiana, they are grown in flooded rice fields as an incidental crop. The crayfish live mainly on the aquatic weeds that grow among the rice. When the fields are drained for harvesting the rice, crayfish congregate by the thousands in the depressions that are the last to dry and can be scooped up by the bucketfull. Some growers cultivate crayfish intensively in rice fields, and harvests of more than half a ton per hectare have been

achieved. Once established, a crayfish population can be self-sustaining if some egg-carrying females are returned to the waterway at each year's harvest.

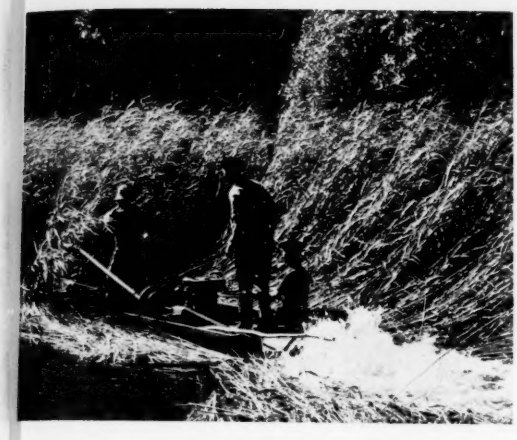
Crayfish should not be introduced into regions of West and Central Africa where the river blindness disease is prevalent. The Simulium fly that transmits the disease sometimes attaches its larvae to the backs of river crabs; it is possible that crayfish would be similarly used. Annual draining is essential in water systems that become infested with predator fish which will rapidly consume the young crayfish. Crayfish avoid tough, woody, aquatic weeds, and do not control such weeds as cattails and water hyacinth.

Others. There are other species of fish [not mentioned here] that consume weeds. In addition, ducks, geese, swans, and other waterfowl forage on vegetation, controlling weeds on the banks of waterways and often clearing aquatic weeds and algae from small lakes, ponds, and canals. These have not usually been considered aquatic weed control agents. However, ducks and geese are small, easily managed grazing animals, well-suited to aquatic areas and wet marshy land. They require little investment to raise, and produce nutritious eggs and highly prized meat. Completely at home in shallow, productive waterways, they are potentially immediately applicable to aquatic weed control in developing countries. The water buffalo, Bubalis babelin, can swim well, and will forage on aquatic weeds. Feeding harvested weeds to water buffalo and pigs (see below) is a promising technique.

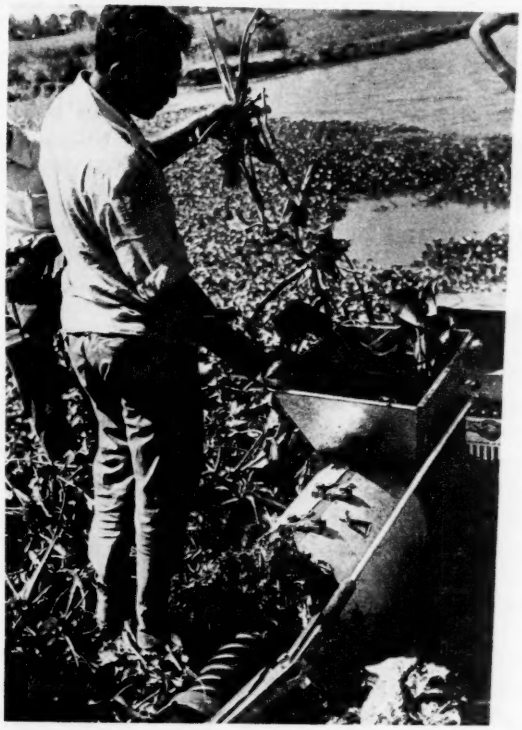
II. Harvesting and Using Aquatic Weeds

Harvesting. Removing aquatic weeds from waterways and selling or utilizing them to defray the cost of removal is an appealing concept. It would result in weed-free waterways while providing an extensive vegetation resource, especially advantageous in countries where forage and fertilizer are in short supply. Additional advantages of harvesting over other approaches to aquatic weed management include the following: possible, but not yet proven, low net cost; reduced dependence on foreign exchange (harvesting reduces the need for imported chemical herbicides); adaptability to labor-intensive techniques as well as to capital-intensive techniques; harmless to terrestrial crops growing near the waterway (unlike some herbicides); can be introduced rapidly to give quick and predictable removal of weeds from specified areas (compared to biological controls); can remove pollutants from the waterway; and can produce useful materials.

Aquatic plants are harvested from a site at the water's edge or with a self-propelled, floating harvester. Shoreside harvesting requires that the plants float to the harvester. Rooted species must be



LEFT: A small mowing boat, designed for cutting reeds and aquatic weeds. (Krinke and Krüger G. m. b. H, Langenhagen, Federal Republic of Germany)



RIGHT: University of Florida screw press for pressing out water, as described in the text, (page 54) shown here pressing water hyacinth.

LEFT: This harvester lifts water hyacinths and moves them into a water-borne carrier at relatively high speeds. (R. G. Koegel)

uprooted or mowed and then moved to the harvester by boat, or by wind and current. Plants can be lifted from the water either by hand or by crane, mechanical conveyor, or pump.

Mobile harvesters are usually expensive machines that sever, lift, and carry plants to the shore. Most are intended for harvesting submerged plants, though some have been designed or adapted to harvest floating plants or the mowed tops of submerged plants.

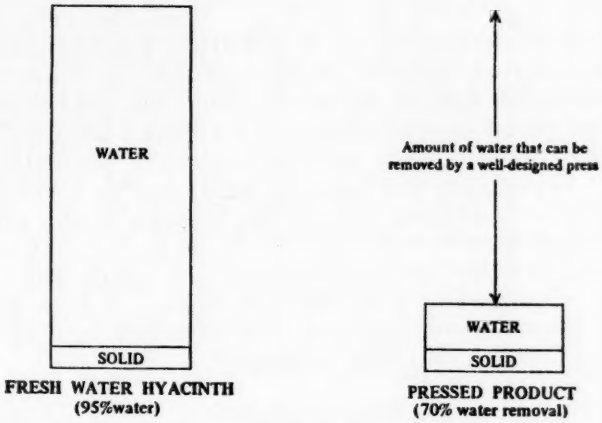
Handling the harvested weeds is a problem. Transporting the plants is difficult and expensive because of their enormous water content. Choppers are often incorporated into harvesting machinery designed for aquatic plants. Chopping makes the plants much easier to handle and reduces their bulk to less than a fourth of the original volume, greatly simplifying transportation, processing, and storage. Some examples of techniques for harvesting aquatic plants are shown in the illustrations.

Dewatering. As noted, aquatic plants contain very large proportions of water, which is the main reason why they are not now harvested and used. When used as feed, for example, a massive 95 kg of water must be excreted by an animal for every 100 kg of fresh water hyacinth eaten. In order to make hay from aquatic plants, as much as 90 kg of water must be evaporated for every 100 kg of whole aquatic plants laid out to sun dry, and this must occur so rapidly that mold and decay do not ruin it (an impossibility in humid or cool climates).

Aquatic plants can be dewatered, however. About half the moisture is on the surface and some is loosely contained in the vascular system. This water can be removed relatively easily by lightly pressing the plant, which removes only about 2 percent of the plant solids. But even with half the water removed, aquatic vegetation may still be too wet for most uses. In order to reduce the moisture further, heavier pressing is required to obtain a product that is comparable to terrestrial forage grasses. For many purposes the vegetation must be "chewed," sheared, or macerated as the water is pressed out.

Depending on plant species, press design, and operating conditions, the water removed can carry with it 10-30 percent of the plant's solid matter, 15-35 percent of the protein. Roller-, belt-, cone-, and screw- presses have all been used to dewater and remove nutrients from vegetation, with varying success. All types are available commercially, but usually in heavy, durable designs that are unnecessarily complex and cumbersome for pressing aquatic vegetation. Lightweight experimental screw presses (suitable for use in developing countries) have been designed. For example, a small screw press of simple design (see illustration) has been constructed at the University of Florida. With its 23-cm bore, this press weighs between 200 and

250 kg. Complete with power plant, it can be carried by truck or boat to remote locations, and can press up to 4 tons of chopped water hyacinth per hour. Such presses are compatible with a program of manual harvest and with the small-scale needs for animal feed in rural areas of developing countries. In addition, these presses can probably be manufactured in the country where they are to be used.



Estimates of water hyacinth pressing costs range from US$5.00 to $10.00 per ton of dry matter, depending greatly on machine cost, machine use, production rate, amortization time, and labor costs. Less than 4 horsepower hours is required to remove a ton of water, leading to an energy cost in the United States of $2.25 per dry ton.

In some arid climates solar drying may be feasible, either by exposing a thin layer of the plants to the sun, or by more sophisticated solar collector-heat transfer systems. Drying aquatic plants with conventional fuel-heated air is economically impractical because of the high moisture content.

Soil Additives. Mineral fertilizers are too expensive for many farmers in developing countries, yet there is a greater need now than ever to increase food production. As an alternative, the 1974 World Food Conference and, more recently, the Food and Agriculture Organization of the United Nations (FAO) have stressed the urgency of reassessing organic fertilization. This includes green manuring and composting; aquatic weeds can be used in both processes.

Aquatic weeds can be used as green manure through a simple process--the plants are either applied to the soil as a surface mulch, or they are plowed under or buried by hand in shallow troughs. As a mulch, they suppress weeds, reduce evaporation, and reduce rain-

fall runoff and the erosion it causes. The problem with this method is that the plants are bulky and difficult to handle and large amounts have to be transported.

Composting is an ancient practice but only in recent years have aquatic weeds been used. Nonetheless, the few experiments conducted to date show that the process is one of the simplest and most useful techniques for using these weed pests. The weeds are harvested and spread out at the water's edge for a day or two. Then the wilted plants are made into a pile with some soil, ash, and a little animal manure. Microbial decomposition begins spontaneously and the resultant bacteria and fungi break down the lipids, proteins, sugars, starches, and cellulose fiber. The piled composting mass retains heat and so involves frequent turning of the pile to maintain aerobic conditions. Tropical temperatures (especially the warm nights) foster decomposition. Warming occurs, and temperatures in the middle of the pile may go to 70°C. At such temperatures only special heat-loving bacteria and fungi survive while those that are pathogenic to humans and animals are killed, as are weed seeds and parasite eggs. In the rotting mass the fibrous weeds decompose, shrink, and crumble into an earthy-smelling, dark-colored, soil-like compost.

Some developing countries have a long tradition of using compost made from other waste materials. Compost raises soil fertility and improves yields, but most of all it improves soil quality. It increases the soil's capacity to absorb and store water (particularly important in heavy, claylike soils); spread on the soil surface, it reduces evaporation, erosion, soil aggregation, and crusting (particularly important in the lateritic soils, widely spread throughout developing countries); and it can help return saline soils to production. Compost thus fits a need in the developing world where commercial fertilizer is expensive, labor cheap, implements simple, and soil structure and water retention a problem. Compost is easily made using manual labor without expensive equipment. Composting can be done on a small or large scale. The fact that compost requires much moisture makes it an ideal use for aquatic weeds--the weeds do not have to be dewatered except by a few days' wilting in the sun, a great savings over other uses in terms of cost and equipment.

Although compost and green manure improve soil quality, the nutrients are less than that obtained from mineral fertilizers. Compost usually contains 1.5-4 percent nitrogen, 0.5-1.5 percent phosphorus, and 1-2 percent potassium, whereas mineral fertilizers are several-fold more concentrated. (However, it is thought that 25-30 percent of the mineral fertilizer nutrients leach to the groundwater and are lost to the crop.) Compost nitrogen is in organic form and is released into the soil only gradually. In about a year, however, all the nitrogen does become available. (This may be an advantage because it extends the availability of nitrogen throughout the growing season.) Compost is bulkier

than fertilizer, and with its lower concentration of plant nutrients large quantities may be needed. Since it can be time-consuming and expensive to apply, composting is most attractive in areas where labor is cheap and plentiful, and where farmers are willing to expend the necessary time and effort. Though aquatic weeds need not be dewatered, composting must be done carefully to avoid waterlogging and resulting anaerobic conditions, which produce foul odors.

Processed Animal Feeds. Many types of vegetation that humans find inedible can be converted into meat, milk, and wool by ruminants--cud-chewing animals, such as cattle, sheep, and goats. It is therefore reasonable to consider aquatic and semi-aquatic plants as potential ruminant feed, particularly as cattle, water buffalo, and other animals are known to graze the leaves of floating aquatic weeds. Aquatic weeds are usually between 10 and 26 percent crude protein (dry matter basis), which is equivalent to, or higher than, that of forages. The leafy parts of aquatic plants, such as duckweed and water hyacinth and some submerged weeds, contain 25-35 percent protein, which is exceptionally high. The individual amino acid constituents are present in about the same proportions as in land forages of similar crude protein content; however, the levels of methionine and lysine--generally considered the limiting amino acids in plant proteins--are often lower than in high-quality terrestrial crops. Nevertheless, many aquatic plants have not been analyzed for amino acid content; that some may be surprisingly good is suggested by a lysine content in water hyacinth equal to that found in milk.

The weeds differ widely in fiber content. Submerged weeds are low in fiber because the water supports their weight; but floating and emergent weeds are fibrous, and reeds, cattails, and other tall weeds contain extreme amounts of fiber. The fiber content of such plants makes them potential substitutes for hay, cottonseed hulls, and other roughages eaten by ruminant animals. Some submerged aquatic weeds, such as hydrilla and water milfoil, are particularly rich in carotenes and xanthophylls and could become new sources for these commercially valuable pigments, which many countries add to poultry rations. While some potentially toxic substances are at times present they also occur in many terrestrial forages, and in general aquatic weeds do not appear to be any more hazardous as feedstuffs than conventional forages.

Nutrient composition is a guide to a feed's value, but high digestibility is crucial if the nutrients are to be available to the animal. The digestibilities of only a few aquatic weeds are known. For water hyacinth experiments indicate that, for a roughage, the nutrients are satisfactorily available to ruminants. In Indonesia, pigs are fed rations containing water hyacinth. In China, pig farmers boil chopped water hyacinth with vegetable wastes, rice bran, copra cake, and salt to make a suitable feed. In Malaysia, fresh water hyacinth is cooked with rice

bran and fish meal and mixed with copra meal as feed for pigs, ducks, and pond fish. Similar practices are much used in Indonesia, the Philippines, and Thailand.

Despite these promising beginnings, many attempts to feed aquatic plants to animals have failed. Failure is apparently due to two features--the high moisture content of aquatic weeds, and their high mineral content. Methods for reducing the moisture content have been generally described. Several approaches are known to be useful specifically for making feedstuffs. 1) Weeds, partially dewatered by chopping and light pressing, can be fed directly to livestock. It seems likely that cattle, water buffalo, goats, sheep, donkeys, and swine could use partially dewatered aquatic weeds in their diets when forage or other nourishment was not readily available--for example, during dry seasons in such countries as Sudan and Bangladesh. 2) Partially dewatered weeds can be sun-dried to a hay. This is difficult to do in the humid tropics, but it appears a promising technique for dry climates. 3) Partially dewatered weeds can be further dried using hot air to yield a stable product that will not mold when stored. It can also be ground into a meal or pelleted for bulk handling. This is an energy-intensive method. 4) Partially dewatered aquatic weeds can be ensiled. In this process, the weeds are placed in a silo, and the naturally occuring bacteria ferment the plant components to produce lactic acid and other organic acids. This process takes about 20 days. Extensive experiments in Florida have shown that pressed water hyacinth produces a palatable, digestible, and nutritious silage that is readily accepted by cattle and sheep. The first large-scale production of water hyacinth silage began in Florida in 1972; no fundamental problems were encountered. Water hyacinth silage can be made successfully using material with an 85-90 percent moisture content--the hyacinth fiber retains water remarkably well; water does not separate to cause anaerobic conditions. Ensiling aquatic weeds could become particularly important in humid tropical and subtropical regions where it is difficult to make hay. Because silage is bulky, silos must be located near the aquatic weed supply and also, if possible, near the market or animals to be fed.

Concerning mineral content: freshly harvested aquatic plants can contain enormous quantities of minerals depending on the plant type and on the conditions of its waterway. The ash content of an aquatic weed can be as high as 60 percent if it is covered in sand, silt, and encrusted carbonates. Such plants make unsuitable animal feeds and have sometimes led researchers to conclude that aquatic weeds cannot be used as feedstuffs. For example, in recent decades several attempts to feed water hyacinth to animals have failed. Today we know that success depends upon selecting the hyacinth in the right stage of growth. Lush, succulent, tall-stemmed hyacinth growing on nutrient-rich waters make much better feed than dwarfed water hyacinth plants, which usually have long roots encrusted with silt. Even the mineral

content within the plant itself affects its feed value; the mineral content reflects the dissolved minerals in the waterway where it grew. In general, while aquatic weeds can be used to supplement animal feeds, they cannot comprise the entire diet because of their frequently high mineral content. Traces of pesticides have sometimes been found in samples of aquatic plants; consequently, the plants must be tested for pesticide residues before being processed into animal feed. Waterways that are excessively polluted with animal or human waste may contain pathogenic bacteria, so plants harvested from such waters should be screened for harmful bacteria before being used in animal diets or handled by man.

Pulp, Paper and Fiber. Tall, grasslike, emergent aquatic plants cover and clog vast areas of marshes and swamps the world over, often impeding agriculture, fishing, recreation, wildlife, and navigation. For decades these weeds have withstood destruction by fire, machines, or chemicals. Reeds, bulrushes, cattails, and papyrus usually grow in pure stands and have been harvested for centuries for food and fiber. As synthetic materials become increasingly expensive in the future, these aquatic plants may be used for those purposes again. Three varieties are of particular interest.

1) The most impressive use of a wetland plant is the Romanian government's program to produce pulp and other cellulose derivatives from the common reed Phragmites communis. More than 60 percent of the huge (4,000 km^2) delta of the Danube River is covered in Phragmites. In 1956 the government began to farm and use it, and now the reed beds are carefully managed and their productivity improved. The reeds are harvested and converted to pulp in mills at Braila, a short distance inland. Printing paper, cellophane, cardboard, and various synthetic fibers are derived from this pulp. The raw reeds and pulpmill wastes yield a variety of other products, notably cemented reed blocks and compressed fiberboard; furfural, alcohol, and fuel; insulation material; and fertilizer. With an annual harvest of about 125,000 tons, farming of the Danube reeds has become important to the Romanian economy.

Extensive stands of Phragmites communis grow on lake margins throughout many of the temperate and subtropical regions of the world. In some areas they cause massive and seemingly intractable problems. The Romanian example illustrates how a reed-filled wetland can be turned to a resource without draining it and totally altering its character. Their system of reed farming is based on the reed's natural production cycle. The reeds are harvested in winter after they have shed most of their leaves. Then without further attention (e.g., plowing, fertilization, or chemical treatment) they are left to grow back naturally from their underground rhizomes during the spring and summer. (At present, only 12,500 ha of 190,000 ha reedlands is harvested each year.) An elaborate gathering and transportation system is maintained,

using tractors, airboats for harvesting swampy areas, and floatable balloon-tired vehicles. The air-dried reed reportedly yields 60 percent of unbleached pulp; the Braila factory pays $85 per ton for raw reeds, reflecting partial subsidy of the project. Reed pulp is mixed with wood pulp to increase the tear strength and the density of the paper that is made from it.

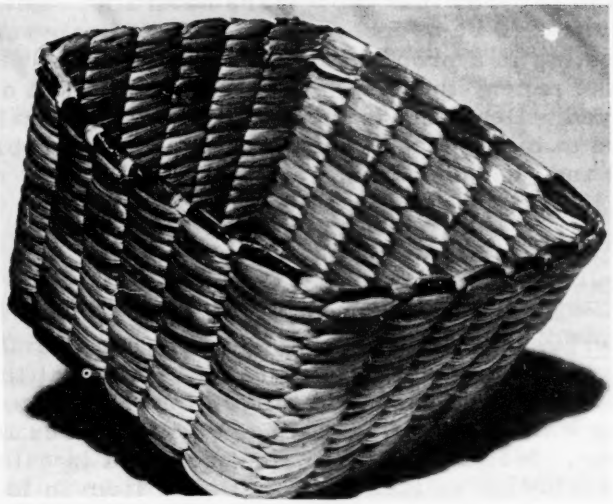
2) Cattails are weeds that present serious problems. Fast growing, they invade new waterways, rice fields and other irrigated agricultural lands, farm ponds, lakes, and canals. Botanically, cattails are special of Typha, and several species similar in physical character are found in fresh and brackish shallow waters all over the world. Of all wild plants, cattails have been called the most useful emergency food source; the rootlike rhizomes contain a firm core that is eaten raw, roasted, or boiled. It is pungent, fibrous, and rich in an edible starch, which can be separated from the fiber as a flour. It is said to contain as much protein as corn or rice and more carbohydrate than potato; one hectare of cattails can yield over 7,000 kg of rhizomes. In times of food scarcity, several nations have considered cattail rhizomes a source of starch and the seeds a source of edible oil and animal feed. Young cattail stems can be eaten in salads or as green vegetable; even the yellow pollen is edible.

Perhaps the cattail's greatest economic potential, however, is as a source of pulp, paper, and fiber. It can probably be cultivated as a fiber crop on wastelands too wet for other purposes. Little is known of its pulping characteristics, but cattail stems and leaves seem suitable for paper-making: a set of books published in 1765 containing pages of cattail paper is still extant. Cattail paper is fairly strong but difficult to bleach. Bleaching would not be essential, however, for production of wrapping paper. Cattail leaves yield a soft fiber that has been used in mats, baskets, chair seats, and other woven articles. Because they swell when wet, the leaves are reportedly good for caulking cracks in houses, barrels, and boats. There are British patents on chemical and mechanical means of extracting cattail fiber, and a German patent on a mechanical process. Stems and leaves together can be chemically treated with sodium hydroxide to obtain fibers 2-4 m long, closely resembling jute. The yield of fiber is 30-40 percent.

3) The papyrus reeds Cyperus papyrus and Cyperus antiquorum form vast stands in swamps, in shallow lakes, and along stream banks throughout Africa. Cultivated in ancient times (3500 B. C.) in the Egyptian Nile delta, papyrus gave its name to the writing material, paper, made from its stem. From the outer fibrous parts of the papyrus stem the Egyptians also made ropes and baskets, wove nets and canvas for boat sails, mats, and furniture coverings; the roots were used as fuel, and the pith made into food. Today the papyrus plant is considered a scourge, something to be destroyed. In some African

LEFT: A traditional boat made of reeds in Bolivia. (Photo: International Center for Aquaculture, Auburn University)

RIGHT: In the Philippines water hyacinth petioles (leaf stalks) are woven to make strong baskets which are soft to the touch. (Photo: D. L. Plucknett and N. D. Vietmeyer)



LEFT: A white-stemmed variety of water spinach (Ipomoea aquatica) for sale in a Hong Kong market. (Photo: D. A. Griffiths)

waters (for example Lake Victoria, the White Nile, the Congo, and the Okavango swamp) large clumps detach from the land and form floating islands that juggernaut around, obstructing navigation and water flow.

Harvesting papyrus for commercial use is seldom, if ever, seriously considered today. Yet, with a growing world shortage of pulp and paper, research could perhaps turn back the clock and make papyrus a valuable resource for Africa once more. Uganda, for example, has about 6,500 km^2 of permanent swamp, much of it covered in papyrus. The exploitation of this ecosystem has generated much controversy, with some proposing to drain it and raise cattle or pond fish, and others proposing to leave it in its natural condition and crop the fish and papyrus that grow there naturally. However, there are many difficulties to be overcome before use of papyrus will be economical. Harvesting is a problem and is expensive; the pulp yield is low; and to make paper, the pith (which makes up much of the stem) has to be removed. Depithing is therefore a key technical problem in papyrus if used to make paper, but the pith is not a problem in making hardboard and, because it is rich in hemicellulose, may have commercial value itself.

III. Other Uses of Aquatic Weeds

Energy. Water hyacinth might one day provide a new source of energy. In a pioneering effort researchers at the U.S. National Aeronautics and Space Administration (NASA) are working on converting water hyacinth and other aquatic weeds into a biogas rich in methane. Methane is the main ingredient in natural gas, which is used worldwide as fuel and is a major item in international trade. The recovery of fuel from aquatic weeds, even if on a small scale, has interesting implications, especially for rural areas in developing countries. As many nations have an apparently inexhaustible supply of aquatic weeds within their borders, this potential energy source deserves further research and testing.

Aquatic weeds are converted to biogas by capitalizing upon one of nature's processes--decay by anaerobic bacteria. Methane-producing bacteria are common in nature. If they are cultured on water hyacinth in a tank, sealed to keep out all air, they produce a biogas composed of about 70 percent methane and 30 percent carbon dioxide. The high moisture content of aquatic weeds is an advantage in this process: it is needed for fermentation. This is one method of aquatic weed utilization that does not require dewatering. Based on NASA's findings, it appears that the water hyacinth harvested from one hectare will produce more than 70,000 m^3 of biogas. Each kilogram of water hyacinth (dry-weight basis) yields about 370 liters of

biogas with an average methane content of 69 percent and a caloric (heating) value, when used as fuel, of about 22,000 kJ/m^3 (580 Btu/ft^3). The biogas burns readily. It can be used for virtually every application where natural gas is used: for cooking, heating, and as a source of power. In a limited way, it has even been used to power stationary engines, tractors, and cars. However, before the gas can be compressed into cylinders for use on equipment, the carbon dioxide must be removed; and unless production is large it may not be practical to use biogas as a fuel for engines.

Anaerobic digestion has been used for about 70 years to transform sludge in sewage treatment plants, and it is attracting increased attention and research activity today. Several thousand digesters (air-tight tanks that permit the growth of anaerobic bacteria) are in operation around the world, notably in India, China, Taiwan, and Korea. These, however, process animal manure or human wastes mixed with vegetable waste. It is not well known that, without any animal manure, aquatic weeds can be digested to methane as the work at NASA shows. But the process is not without difficulties.

Fermenting aquatic weeds to methane may be accomplished without dewatering, but the weeds usually have to be chopped or crushed to make them more available for bacterial attack. Although simple, cheap equipment can be used for fermentation chambers, they must be constructed and maintained with care. The initial start-up is slow because the bacteria take time to build up a population big enough to ferment the weeds; 10-60 days may be needed. Experience with existing biogas generators has shown that the bacteria are sensitive and easily "upset." It takes skill and continual supervision of temperatures, input mix, and attention to acidity levels to maintain methane production. More research on many aspects of the process is needed and could be important.

Wastewater Treatment. Raw sewage contains complex organic and inorganic materials, including proteins, urea, amines, cellulose, fats, carbohydrates, and soaps. In biological sewage treatment facilities bacteria, fungi, zooplankton, and algae degrade and use these complex materials, leaving an effluent rich in nitrogen, potassium, phosphorus, and other elements. Treated waste has usually been discharged into the nearest lake or river with little thought of the consequences; today, however, the growing world population and an increasing demand for an improved environment make better disposal mandatory.

Recently, researchers have discovered that some aquatic weeds can scavenge inorganic, and some organic, compounds from water: the weeds absorb and incorporate the dissolved materials into their own structure. Effluent renovated by the plants is stripped of its pollutants and, when released into waterways, causes less environmental damage. The plant units clean water so rapidly and effectively that they are now

seriously being considered for use as a "final polish" in sewage treatment. The clean water produced is, in most situations, suitable for re-use in irrigation and industry, though not necessarily for drinking. Furthermore, the plants themselves can be harvested and used, thus providing additional benefit. The technique can also be used for treating animal manure and other farm wastes.

For developing countries this could become extremely important. Nitrates, ammonium compounds, phosphates, and organic carbon discharged from sewage treatment facilities are nutrients often needed in agriculture. The first two are the primary ingredients in fertilizer, which today costs increasing amounts of foreign exchange to import. Aquatic plants promise to provide an indigenous source of cheap fertilizer and soil conditioner available within regions that need it most; when grown in waste water effluent, their nutrient content is much higher than it is when composted after growing in ordinary water.

This fertilizer recovery method is simple to carry out. Wastewater effluent is led to shallow ponds planted with aquatic weeds. The resultant crop can be harvested regularly, each time leaving some plants to regrow a new crop so that the water purification becomes a continual process. Alternatively, the plants may be allowed to grow for an entire season and then harvested--perhaps even after draining the pond. This method is versatile and can be scaled for village, farm, or small municipality. It can be used to treat raw sewage or raw farm wastes but they should first be lagooned or diluted. Wastes from households and food processing can be purified by this process too.

In addition, aquatic weeds can be used to partially strip traces of potentially harmful, or odorous agents from drinking water including cadmium, nickel, mercury, phenol, and potential carcinogens. The aquatic plants remove and concentrate these elements, which may become 4,000-20,000 times more concentrated in the plants than in the water. One research effort is now under way to see if aquatic plants can profitably recover silver, gold, and other precious metals from ore-refining wastewaters.

An aquatic weed water-treatment system can be inexpensive to build and maintain and, if it is situated so that gravity delivers the wastewater, has virtually no energy costs other than for planting and harvesting the weeds. In a sense the plants are an agricultural crop utilizing solar energy and growing on the nutrients in the wastewater. The harvested plants can be used as described elsewhere in this report to feed herbivorous fish, waterfowl, cattle or to provide raw material for making processed animal feed, soil additives, methane gas, and other products. Not all aquatic plants are equally adapted for growing on wastewaters. But many of those that seem to grow best are common weeds such as the common reed Phragmites com-

munis, bulrush Scirpus lacustris, water hyacinth, duckweeds or forms of elodea.

The vigor that makes it one of the world's worst weeds appears to make the water hyacinth ideal for water treatment. Several research groups in the United States have selected it for study. For example, water hyacinth already is being "farmed" on a 3.6 ha sewage lagoon serving the city of Lucedale, Mississippi (population 2,500). The University of Florida and the Texas State Department of Health Resources are also treating sewage with water hyacinth on an experimental basis. During warm weather in these subtropical southern states, water hyacinth can increase at a phenomenal rate of 15 percent surface area per day. At this rate 20-40 tons of wet water hyacinth could be harvested per hectare per day, removing the waste of over 2,000 people. Under ideal conditions water hyacinth has recovered the following elements:

Element	Amount Recovered (kg/ha/day)
Nitrogen	22-44
Phosphorus	8-17
Potassium	22-44
Calcium	11-22
Magnesium	2-4
Sodium	18-34

The Max Planck Institute of West Germany has developed and patented a water treatment process that uses reeds and bulrushes to purify the water. The untreated wastewater first passes through a bed of gravel topped with sand in which common reed is planted. The reeds quickly grow to be 2-4 m tall and spread their roots through the gravel. Wastewater is spread over the surface of the bed, and solid particles are trapped on the sand as the water percolates downward. Dissolved organic and inorganic material is absorbed by the reeds or decomposed by the microorganisms in the gravel. Since leaves, stems, and roots of the common reed have air passages in them, oxygen is transported down through the plants and outward from the roots to the soil to supply the massive needs of the microorganisms. By creating a route for rapid transport of oxygen to deep portions of the bed, the plants increase the efficiency of the breakdown of organic material. As sludge accumulates on the surface of the bed, the reeds put out new roots from along the base of the stem. These roots aid in digesting the sludge and slow the rate of sludge build-up on the surface of the bed. The water then flows to the site of the second stage of the process, a gently sloping bed of gravel planted with the bulrush. As the water percolates across this living filter, the plant absorbs more organic materials and inorganic nutrients. Colloidal substances in

the water flocculate and settle out as a result. In the presence of the bulrush, bacteria and other pathogens in the sewage are significantly reduced.

A similar system developed in the Netherlands uses long ditches, largely because they can be maintained mechanically. In this system, however, no gravel is used, and the plants are rooted in the bottom soil. Under Dutch conditions, the initial investment and the annual operating costs for using their aquatic plant method are reported to be only a sixth and a fourth of the equivalent costs for an activated sludge plant with the same capacity. The water leaving these units is clear, neutral (about pH 7), and will not exert an oxygen demand on the receiving waters. The reeds and bulrushes are harvested periodically.

Growing Aquatic Plants for Food. Many food plants grow in the world's fresh waters, but except for rice none has been the subject of concentrated research. A few aquatic plants are farmed, most by traditional methods. Modern technology has seldom been applied to the cultivation of aquatic plants, a grossly neglected area of aquaculture: fish and shellfish receive much attention, while the production of edible aquatic plants receives virtually none. In the near future, as burgeoning populations force us to utilize increasingly marginal agricultural areas, aquatic plants may be cultivated more intensively. In most parts of the world there are swamplands and shallow ponds totally unsuited to conventional fish culture or agriculture. Man's present policy toward such areas is to drain and "develop" them for uses for which they may not be well suited. We should find ways that will allow us to use wetlands as wetlands, and cultivating aquatic plants is one possible way. Aquatic plants can provide three types of food: leaves for use as a green vegetable; grain or seeds that provide protein, starch, or oil; and swollen fleshy roots that provide carbohydrate, mainly starch. Some examples are the following.

Water Spinach (Ipomoea aquatica) is a tropical trailing herb of muddy stream banks and freshwater ponds and marshes native to India, Southeast Asia, Taiwan, and southern China where it is cultivated most. It has been introduced successfully to Fiji, Hawaii, and Florida. Its fresh young leaves and stems are used as a vegetable, boiled or cooked in oil, especially during the summer months when other leafy crops do not grow well. It is also used for pickles. It is very popular in Hong Kong and comprises about 15 percent of all the vegetables produced for the local markets. Much is also used as fodder for pigs, cattle, and fish. Farmers favor water spinach because it is easy to grow, has relatively low labor requirements, and can be harvested irregularly to fit the market.

Watercress (Nasturtium officinal) is an herb of the mustard family native to Europe and northern Asia. It has also been widely cultivated

in temperate and subtropical regions of the world and is grown at cool altitudes in tropical zones. Prized as a fresh-salad herb or as a cooked green vegetable, it is a rich source of iron, iodine, and vitamins A, B, and C. The plant needs cool or cold streams and grows submerged, floating, or spread over mud surfaces. It is usually cultivated in beds flooded with flowing water up to 10 cm deep. Rapid growing, the plants can reach 30 cm high and be ready for harvest in 30-60 days. The tops are cut off below water level and are soon replaced by new growth. In the wild, watercress perpetuates itself year after year. If the water is polluted, however, watercress can become contaminated with amoebae and is dangerous to eat raw unless washed with disinfectant.

Floating rice, or deep-water rice, grows on about 10 percent of the world's rice land. Most is grown by subsistence farmers in the densely populated river valleys and deltas of Bangladesh, India, Burma, Thailand, the Khmer Republic, Vietnam, Indonesia, and parts of Africa. In these areas the water depth during the growing season can be too deep for standard rice varieties, particularly the new high-yielding, semi-dwarf ones. Farmers usually broadcast the seeds in dry or moist soil before the heavy rains begin. As the monsoon rains raise the water levels, in some places to a depth of several meters, the stems rapidly elongate, keeping the leaves above water. Floating rice is sometimes harvested from boats. In areas where the water recedes before harvest, a tangled mass of stems and curving shoots is left behind. Research on floating rice is still in its infancy; but in 1975 the International Rice Research Institute announced that one variety (1442-57) can elongate as flood waters rise by as much as 180 cm, and can produce up to 3 tons per ha in conditions where traditional tall plants are destroyed.

Lotus (Nelumbo nucifera) is widely cultivated in the Orient, and the seeds and roots (rhizomes) used in a variety of cooked and fresh dishes. The lotus is grown from rhizome "eyes" or from seed. The rhizomes can be harvested in under 9 months, and yields up to 4,600 kg per ha have been reported. Rhizomes are marketed fresh, dried, canned, or as a fine white starch. They are often cooked in curries and other Indian dishes. Among Chinese populations the world over there is a constant demand for lotus roots. Both dried and canned, the rhizomes sell for high prices. Protein content is about 2.7 percent. The thick, cylindrical roots--60-120 cm long and 5-10 cm in diameter--have longitudinal air channels so that the sliced root look like Swiss cheese. The seeds are eaten raw, cooked, candied, ground to flour, or canned (after peeling and removing the bitter embryo). In different parts of India the flowering stems and young fruits are also eaten.

Chinese Water Chestnut (Eleocharis dulcis) is also a valued vegetable delicacy throughout the Orient. The tuberous root (corm) of the Chinese water chestnut is now an important item in international commerce and brings high prices. Firm and white, the tubers retain their crisp,

applelike texture even after cooking. In China they are widely eaten like fresh fruit. The Chinese water chestnut plant (also known as "matai") is cultivated in flooded fields, often in rotation with paddy rice. The water chestnuts are produced in large quantities on underground roots (rhizomes). Small "seed" tubers are first raised in nursery beds then, like rice, transplanted to the field, which is soon flooded and left. Six months later, the field is drained and the tubers harvested; yields can exceed 7 tons per ha.

Taro (Colocasia esculenta) is a tropical crop that is commercially exploited in only a few countries. It can be grown under swampy conditions or in flooded paddies like rice. It produces tuberous roots with a nutty flavor that can be used as a rice or potato substitute. Though a particularly promising crop for aquatic situations, taro receives little research support.

Other plants which are of interest for growing in water include wild rice, arrowhead, swamp taro, azolla (ferns), and spirulina.

[Extracted from Making Aquatic Weeds Useful. Report of a Panel of the Advisory Committee on Technology Innovation, Board of Science and Technology for International Development. U. S. National Academy of Sciences, Washington, D. C., 1976.]

DESERTS

DUNE FIXATION WITH SACCHARUM AEGYPTIACUM PLANTS IN LIBYA UNDER THE SUPERVISION OF FAO FORESTRY EXPERTS. (PHOTO: FOOD AND AGRICULTURE ORGANIZATION)

Spreading Deserts: The Hand of Man

Erik Eckholm and Lester R. Brown

[While deserts are not new in history, they are spreading and are affecting the lives of more millions of people. The spread is a result of the effects of human actions, rather than of changing weather conditions. This article reviews the evidence on these questions, and points to the impact on food production in the affected areas.]

More than a third of the earth's land is arid or semi-arid, but less than half this area is so naturally dry and barren that it cannot support human life. Year after year additional land is converted to waste by humans, who are in many cases forced to compromise their futures by circumstances beyond their control. As a result of the unsound use of land, deserts are creeping outward in Africa, Asia, Australia, and the Americas, and the productive capacity of vast dry regions in both rich and poor countries is falling. About 630 million people--14 percent of the world's population--live on arid or semi-arid lands. Some 78 million of these people, according to United Nations estimates, live on lands already almost useless because of such factors as erosion, dune formation, vegetation change, and salt encrustation. Those whose livelihoods are not grounded in agriculture may be able to avoid personal disaster amid ecological decline; but perhaps 50 million of these nearly 80 million people face the gradual loss of their livelihoods as their fields and pastures turn into wastelands. They do daily battle with undernutrition, disease, and, when the rains fail, sometimes even starvation. In growing numbers

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these dispossessed are flocking to overcrowded cities to compete with the rest of the landless for food and jobs.

The worsening plight of people in the arid zones had long gone unnoticed by most of the outside world. But in 1972, as word spread of a great drought and famine south of the Sahara Desert, countries like Chad and Upper Volta suddenly appeared in front-page newspaper stories. The hollow faces and match-stick limbs of starving humans haunted television screens around the world, and the term "the Sahel", became common journalistic coin. [See Development Digest April, 1975, pp. 49-90.] In fact, the drought affected not just the Sahelian countries, but parts of many others. Although the Sahelian tragedy received more publicity, famine in Ethiopia during the early seventies probably took more lives than the six Sahelian countries together lost. As awareness of the misery and dislocation of millions of Africans grew, so did the realization that something more than a hiatus in the Saharan fringe's typically low rainfall was occurring. The ecological calamity triggered by the drought had been stewing for decades. Its roots lay in social and economic patterns incompatible with the region's environmental limitations, and these continued after the rains returned to most of the Sahel in 1974.

Disasters in the desert are nothing new; droughts and crop failures have always plagued arid lands, as Joseph recognized in ancient Egypt when he advised the Pharoah to set aside grain reserves. But the scale of destructive human pressures on delicate arid-zone ecosystems are reaching unprecedented proportions in the Sahel and in many other desert regions. As the number of people who rely on the pastures and croplands of the arid zones climbs, once-sustainable social patterns and production techniques begin to undermine the biological systems on which life depends. Traditional means of coping with drought and of living peacefully with the environment have been rendered inadequate by the modern political and social order, but "development" has not offered desert-dwellers alternative ways to live on the land. Social systems and ecosystems are thus on a collision course; and social and economic patterns in many arid zones will have to change. Either humans will initiate the economic and political reforms and the technological and demographic changes needed to protect the land's productivity, or events--labeled "natural catastrophes" when they occur--will impose social changes as production falls to an ever smaller fraction of its potential.

Desertification: A Global Problem

The term "desertification" has only recently entered the common parlance of the international development community. Once little-

known outside scientific circles, the problems encompassed by this concept were the subject of a United Nations Conference on Desertification in September, 1977, to which governments from all over the world sent representatives. All the problems usually covered by "desertification" involve ecological changes that sap land of its ability to sustain agriculture and human habitation. To many, desertification evokes an image of desert sands relentlessly engulfing green fields and pastures. Such a dramatic encroachment is a genuine threat in some areas, but in most cases one might more accurately think of the desert being pulled outward by human actions. Where desert edges are moving outward, moreover, the process seldom involves the steady influx of a tide of sands along a uniform front; rather, climatic fluctuations and land-use patterns interact to extend desertlike conditions irregularly over susceptible land. Spots of extreme degradation are especially apt to grow, for example, around water holes when the nearby pastures are heavily grazed and trampled, and around towns when people denude adjacent lands in their search for firewood.

The degradation of patches of rangeland and cropland throughout the world's arid and semi-arid zones occurs wherever land is abused regardless of the proximity of true, climatically-created deserts. Where land abuse is severe and prolonged, and especially where extended drought intensifies its effects, grasslands and fields can be reduced to stony, eroded wastelands--or even to heaps of drifting sand. More commonly, the quality of rangeland vegetation declines as the more palatable and productive plants are nudged out by less desirable species. On croplands, yields may gradually fall as soil nutrients are dissipated and the topsoil is eroded by wind and water.

Where and at what pace is desertification unfolding? Documentation is poor, even on current soil conditions in many affected areas, let alone on changes in conditions over time. Still, scientists have used available facts to make valuable estimates of the extent of desertification in various regions. A particularly bold effort has been made by an eminent Egyptian ecologist, Mohammed Kassas. Detailed surveys of climatic data, he observes in a report to the United Nations Environment Program (UNEP), indicate that 36.3 percent of the earth's surface is subject to low rainfall which could make it extremely arid, arid, or semi-arid--categories he combines under the general heading of "deserts". Yet a world survey of land conditions, based on soil and vegetation data, indicates that 43 percent of the earth's surface falls within these categories. The difference of 6.7 percent, Kassas suggests, is accounted for by the estimated extent of manmade deserts. Though it is only a rough approximation, Kassas' estimate does suggest the problem's scale. And regional estimates of the spread of deserts and the degradation of semi-arid lands support the belief that desertification is growing in magnitude.

According to researchers for the U.S. Agency for International Development, an estimated 650,000 square kilometers of land once suitable for agriculture or intensive grazing has been forfeited to the Sahara over the past fifty years along its southern fringe. The spread of the Sahara has probably been measured most precisely in Sudan. There, as elsewhere, vegetational zones are shifting southward as a result of overgrazing, woodcutting, and accelerated soil erosion. When an aerial survey of Sudan's desert margins was completed in 1975, the photographs were compared with maps that had been prepared in 1958. Examining the line at which scrub vegetation tapers off into barren desert, H. F. Lamprey concluded that the desert boundary had shifted south by an average of about 90-100 kilometers in the last 17 years. Observations of tree and scrub cover in Sudan suggest a similar pace of degradation. Dense concentrations of the Acacia tree, ubiquitous in many arid zones and useful for firewood, forage, and (in the case of certain species) gum-arabic production, were common around the Sudanian capital of Khartoum as recently as 1955; by 1972, the nearest dense Acacia stands stood ninety kilometers south of the city. Sudan, it is frequently observed, has the theoretical potential to become the breadbasket of the Arab world, given the presence of still unused lands and unexploited rights to Nile River waters. But if the deterioration of Sudan's natural resources is not soon halted, at least some of this potential will dry up.

Land along the northern margins of the Sahara has met with much the same fate. The population of arid North Africa has multiplied sixfold since 1900, and the destruction of vegetation in Morocco, Algeria, Tunisia, and Libya has accelerated apace--particularly since about 1930, when the region's population began to grow more rapidly. Overgrazing, the extension of grain farming onto lands that cannot sustain it, and firewood gathering have resulted in the loss of more than a hundred thousand hectares of range and cropland to desert each year. This one-time granary of the Roman Empire is now a major food-importing region; despite petroleum and phosphate exports, millions have migrated to Europe for work. Desertification is also a major problem in parts of southern Africa, particularly in Botswana. Vast semi-arid grasslands in Kenya, Tanzania, Ethiopia, and elsewhere have been seriously damaged by overgrazing. But its hold is particularly long-lived and advanced in the Middle East and Western Asia. The arid landscape of this region has suffered many centuries of overgrazing, deforestation, and imprudent cropping. Expanses have been irreversibly transformed by humans into desert, and some areas support fewer people today than they did thousands of years ago. The rangelands of northern Iraq, forage specialists figure, can safely sustain only 250,000 sheep without degradation--a far cry from the million or so that are currently eating away this resource base. Likewise, Syria's ranges currently feed triple the number of grazing

animals they can safely support. In the initial stage of such degradation, inferior plant species replace more useful varieties. Then, sheep pastures become suitable only for the hardier goats and camels. Finally the plant cover disappears, as is apparent where the rangelands have turned into semi-deserts covered with a layer of gravel. Rain-fed farmlands in much of the Middle East also show signs of ecological decline, although national net production increases resulting from expansions in the irrigated area and in the total cropped area have helped to hide this decline in productivity.

Northwestern India is the world's most densely populated arid zone--a distinction that may turn out to be an epitaph. On average, more than 61 people now occupy each square kilometer of India's arid lands, which include the sandy wastes of the Thar Desert of western Rajasthan; a larger inhabited but desolate area surrounding it called the Rajasthan Desert; and other dry areas farther south and east. This density is a small fraction of that supported in nearby irrigated valleys, but it is, as scientists at India's Central Arid Zone Research Institute recently observed, quite high in view of limited resources. The practical consequence of this pressure has been the extension of cropping to sub-marginal lands, which has helped make northwest India perhaps the world's dustiest area. Meanwhile, the area available exclusively for grazing in western Rajasthan dropped from 13 million to 11 million hectares between 1951 and 1961, while the population of goats, sheep, and cattle jumped from 9.4 million to 14.4 million. The livestock population has since continued to grow while the cropped area in western Rajasthan expanded further during the sixties from 26 percent to 38 percent of the total area. The net effect has been to squeeze the grazing area even more.

Desertification is taking place in many of the Western Hemisphere's drier regions. In the Argentinian states of La Rioja, San Luis, and La Pampa, desert-like environments are being created. Large areas of Mexico and the southwestern United States have been degraded by overgrazing and woodcutting in the years since the Spanish invasion. The semi-arid part of Brazil's Northeast is being desertified and, according to Brazilian ecologist J. Vasconcelos Sobrinho, desert-like zones are expanding in more humid interior portions of the Northeast as a result of the massive destruction of forests by ranching corporations and land-hungry farmers. In Chile's arid Coquimbo Region--which divides the lifeless Atacama Desert to the north and the productive irrigated valleys of central Chile--cactuses have replaced shrubs on some overgrazed lands, and on others native perennial plants have given way to less productive annuals and foreign species. As these pastures decline in quality, sheep replace cattle and then goats replace sheep. At the same time, the cultivation of hillsides has led to massive soil erosion and, on the steeper slopes, to a total loss of topsoil.

Desertification is by no means confined to less developed countries. Ill-managed rangelands in Australia have lost productive plant species and topsoil. The dissolution of the American Great Plains into the Dust Bowl of the 1930s showed all too graphically the perils of plowing up lands best left in grass--just as the subsequent recovery and prosperity of much of that same area showed the benefits of better land husbandry. Overgrazing remains a major problem throughout the western U. S. While desertification clearly plagues rich as well as poor countries, the same processes of deterioration can have different effects on human life. Wealthier countries with diversified economies and public welfare programs can generally absorb localized declines in productivity without human catastrophe. But tens of millions of Africans, Asians, and Latin Americans have nowhere to turn when the basis of their livelihood erodes.

Droughts Are Inevitable

Water gives life to the desert, and a long-term shift in rainfall patterns can by itself transform the ecological character of a region. When deserts appear to be spreading, questioning whether climatic change might be the real culprit is only natural. Unfortunately, our understanding of climatic change and our knowledge of historical weather trends in most desert regions are too limited to support conclusions. Theories on the causes and nature of world climatic change are now almost as numerous as the scientists who study the problem seriously. That major climatic changes have occurred over exceptionally long time periods may not be hard to prove. For example, no climatologists doubt that the Indus River civilization flourished four thousand years ago in a moister climate than Pakistan enjoys today. But determining whether a present-day drought reflects a twenty-year dry cycle, a two-hundred-year cycle of rainfall patterns, the beginnings of a new climatic age, or simply a random event is far more difficult.

Pointing to the unusual weather patterns and frequent droughts of the last decade, some analysts hold that a long-term change in the world's climate is an important cause of desertification. However, according to F. Kenneth Hare of the University of Toronto, who has reviewed available evidence on climate and desertification for the U. N. Conference on Desertification, there is "no firm basis for claiming that the extreme weather events of the 1970s are part of a major climatic variation." Extensive reviews of available rainfall records from North Africa reveal no evidence that rainfall has tapered off over the last one hundred years. Nor have Indian scientists studying the Thar Desert found any signs of recently increased aridity on its fringes. Similarly, available evidence indicates that rainfall levels in the Middle East have remained roughly the same for the last 5,000 years.

South of the Sahara, as E. G. Davy concluded in a study of the Sahelian drought for the World Meteorological Organization, "no serious analysis of available data is known to show a falling trend of rainfall in the zone over the periods for which records are available." The length of the recent Sahelian drought proves nothing by itself, for droughts have lasted as long in the past.

Some analysts believe that the landscape denudation associated with desertification may have a self-reinforcing climatic impact--prolonging or increasing the likelihood of droughts and, hence, of further devegetation. By some theories, the increased reflection of solar radiation from the surface that occurs when land is stripped of trees and grasses may reduce the rainfall within a localized region; by others, a rising load of dust above a wind-eroded terrain suppresses potential rainfall. If such localized interactions between denudation and drought do exist, however, they can apparently be overridden by global climatic patterns--otherwise, droughts, once under way, might never end. A few climatologists go one step farther and hypothesize that worldwide desertification and deforestation have already altered surface reflectivity (or, depending on the theory, atmostpheric dust levels) enough to affect the global climate.

Probably the most significant effect of devegetation on the local water balance has to do not with climatic change but rather with the land's ability to capture and use what rain does fall. Rain striking barren, trampled, or sparsely vegetated ground is more apt to run off the surface than to soak in; not only are underground water and springs thereby left unregenerated, but the rate of soil erosion and the incidence of floods after heavy rains also rise. Depleted of their organic matter and structurally destroyed, soils can lose the ability to retain moisture from one rainy season to the next. Consequently, the natural vegetation may then shift to hardier species, while the loss of soil moisture and increased erosion sap the productivity of croplands. Thus, even when rainfall remains constant over time, land abuse can transform an area's plant life into that normally associated with a drier climate.

Whether or not any climatic change is occurring, the experience of the world's drier zones makes it clear that droughts are unavoidable in arid environments. Although not precisely predictable, they should never come as a shock. Nor should droughts be perceived as unexpected natural disasters like tornadoes or earthquakes. Instead, they should be anticipated as harsh facts of life. Agriculture and social institutions in the desert must both be shaped to survive the driest years, not to push the land to its limits in years of good rainfall. Any other approach promises death and dislocation every time the rains fail for long.

The destruction of vegetable cover, the wind erosion of cultivated fields, and the formation of unusable wastelands all peak during droughts. Years or decades of steady rainfall encourage the growth of forage, the multiplication of herds, and the extension of cultivation to lands more safely left in grass; they also breed false confidence about the carrying capacity of the land. Then, when the rains finally fail, overabundant animals eat every available blade of grass on the weather-decimated rangeland until finally many starve to death, especially around wells. Tree-climbing goats eat the last bit of greenery, leaving behind wooden skeletons for the firewood gatherers. Crops fail to take root in the parched ground. The bare, plowed soil yields to the wind, and a dust bowl is created. If the rains remain absent long, sand dunes appear where none existed before. Nomads, farmers, and their surviving herds retreat before denuded lands, setting in process a self-reinforcing negative spiral as more and more refugees overcrowd and overgraze more and more land.

The years immediately following a severe drought can nurture bogus optimism about the land's capacity. By killing off a share of the herds and driving some of the former inhabitants from a region, nature has temporarily restored a shaky equilibrium. Smaller herds make more manageable demands on grazing lands, and returning rains bring grasses and shrubs back to life wherever the soil has not been seriously damaged. But then refugees trickle back and, unless some new force intervenes to break the pattern, the same deadly cycle begins again.

Food Prospects in Desert Lands

Nearly all people in less-developed arid countries make their living from agriculture. The vast majority either grow their own food or sell or trade their crops for food and money. Unfortunately, many desert countries have fallen far behind the world as a whole and even behind many other poor countries in efforts to boost food output. Judged strictly on the basis of national per capita production data, desert lands appear to be in deep trouble. Worldwide, grain production doubled and world population increased by nearly two-thirds between 1950 and 1975, so that global grain output per person rose by more than a third. Few of the desert countries, however, shared in this progress. In fact, per capita grain output fell during this period in many. Data from sixteen predominantly arid or semi-arid developing countries that lack widespread irrigation are shown in Table 1.

Only two of the sixteen countries--Senegal and Sudan--boosted per capita grain output significantly. By irrigating and cropping

Table 1: Per Capita Grain Production in Sixteen Desert Countries, 1950-52 and 1973-75

Country	Per Capita Cereal Production (Kilograms)		Change (Percent)
	(1950-52)	(1973-75)	
Afghanistan	263	234	−11
Algeria	221	87	−61
Ethiopia	220	190	−14
Iran	182	185	+ 2
Iraq	269	156	−42
Jordan	143	79	−45
Lebanon	44	20	−54
Libya	99	106	+ 7
Mali	267	146	−45
Morocco	272	213	−22
Niger	303	169	−44
Senegal	142	186	+31
Sudan	102	150	+47
Syria	315	241	−24
Tunisia	216	184	−15
Upper Volta	193	180	− 7

Source: U.S. Dept. of Agriculture.

more land, these two countries overcame the effects of marked land degradation in some of their regions and nearly matched the average global improvement rate. In Iran and Libya, grain production per person held its own over the last quarter century. But in the remaining twelve countries per capita grain output declined, and in Algeria, Iraq, Jordan, Lebanon, Mali, and Niger per capita production fell by at least 40 percent. In none of the countries showing declines was much grain-producing land shifted into non-food crops during these years (in some, sizable areas are devoted to export crops such as cotton or peanuts).

Because of poor national food-production records (and, in a few countries, soaring net incomes from oil wealth), net grain imports into these sixteen countries have more than tripled over the last fifteen years, rising from an annual average of 2.5 million tons in 1961-63 to an average of 7.6 million tons in the years 1975-77. Algeria and Lebanon already import half or more of their total grain supply, as does Saudi Arabia (a desert country excluded from the list because data on its grain production is inadequate). Despite its intensive irrigation development, Egypt is also growing heavily dependent upon grain imports.

While different arid regions have different agricultural prospects and potentials, desertification reduces present and future food production wherever it occurs. It undercuts the benefits of agricultural investments and can create poverty-producing wastelands even in

countries that, judged by aggregate national statistics, appear to be making rapid agricultural gains. In a number of desert countries, water resources are far from fully exploited. But the physical availability of underground or river waters cannot automatically be equated with irrigation potential; sometimes the costs of water development outweigh the resulting benefits. Furthermore, waterlogging, salinity, and the spread of water-borne diseases are common perils of irrigation in arid lands. Arable lands remain unplowed in a few desert areas: fertile areas are being opened to farming, for example, as a result of the current international campaign against river blindness (onchocerciasis), fear of which has kept portions of West Africa's river valleys unoccupied. In more desert regions, however, such as Northwest India and many parts of Africa and the Middle East, farming has already been extended to areas where rainfall is fickle and soils are highly erosive. In these areas good husbandry will probably require reducing the cropped area.

In the wake of the Sahelian drought, development specialists rightly focus their attentions on the unexploited food-producing potential of the arid zones and on the possibility that some now-destitute areas could become breadbaskets. Even as the reforms and investments essential to such development are identified and implemented, however, some basic influences on the future food situation in desert lands must be held in mind.

Most of these lands will never be irrigated. While substantial production gains could be realized in many desert countries, no technology within sight could sustain progress in dryland grain farming comparable to that enjoyed in moister zones in recent years. Research priorities within the arid zones have been skewed toward the development of profitable export crops, and until recently worldwide efforts have reflected mainly the needs of farmers in temperate zones. But more fundamental constraints on dryland yields may exist; heavy fertilization is productive only when soil moisture is high. Even in the United States, the average yield of wheat--which is grown mainly on semi-arid lands--has increased by only two-thirds over the last generation while the per-hectare yield of corn--which is grown mainly where rainfall is abundant--has tripled. No less skilled or progressive than the Iowa corn farmer, the Kansas wheat farmer must simply work with drier soil. Indeed, wheat yields have risen by scarcely a third in recent decades in Canada and Australia, two other agriculturally advanced countries that produce wheat under dry conditions. In contrast, where wheat is grown under high rainfall (as it is in Western Europe) or under irrigation (as in Pakistan and Mexico) impressive advances have been achieved.

Demography as well as production influence the food outlook in desert countries. Although undernutrition mainly results from the

distribution of income rather than from an absolute shortage of food, its extent can easily multiply if population growth far outpaces agricultural growth. Sometimes, a whole nation's economic progress can be undermined as foreign exchange is soaked up by rising food imports for increasing numbers of people. In eight of sixteen desert countries analyzed, populations are now growing at 3 percent or more annually--a growth rate that, if sustained, would bring population increases of nineteenfold or more within a century.

Populations in many arid regions have, in the context of the technologies in use there, already reached the ecological danger point--as the breakdown of traditional fallow cycles and the spread of desert-like conditions make all too clear. In the arid, overgrazed area directly on the fringes of deserts, populations must, virtually all analysts agree, be stabilized soon if further disaster and desertification are to be skirted. As Australian demographer John C. Caldwell writes of the Sahelian zone nomads, "their way of life is, without question, being imperiled by their growth in numbers."

Brightening the food prospects of the desert lands will require arresting and reversing desertification rapidly. It will entail implementing rural agricultural reform and distributing the fruits of development more equitably. It will also require slowing population growth. In the absence of such progress, economic and nutritional deterioration in many desert countries will continue. If it does, those individuals and countries able to afford it will buy their food on world markets; others will make do as best they can.

[Extracted from Spreading Deserts--the Hand of Man, Worldwatch Paper 13, August 1977. Copyright © by Worldwatch Institute, Washington, D. C.]

Recovery from Desertization

H. N. Le Houérou

[The spread of deserts can be halted and reversed. This article summarizes the principal methods which can be used. The main difficulty is not a lack of technical knowledge but the fact that necessary actions are politically problematical, as they require some people to change their habits and abandon current means of obtaining a living.]

Since desertization is a man-induced phenomenon, aggravated by climatic circumstances, any requisite measures for halting further irremediable loss of productivity and for restoring desertized land to productivity must necessarily interfere with human behavior and land-use management. Halting desertization in arid areas in technologically advanced countries such as the United States or Australia is not a major problem, owing to the very low densities of population. However, in the North African, Near and Middle Eastern arid zones, the problem is entirely different owing to the pressure and sharp growth rate of their populations--doubling every 20-25 years. In central Australia a rancher lives on 10,000 to 1,000,000 hectares, whereas in climatically similar areas a Tunisian, an Algerian, or a Syrian has to take out his living from 10 hectares, and sometimes less, of non-irrigated land.

Biological Recovery

The cures for desertization have been known for a long time: they consist of the reverse processes, that is, biological recovery or biological revival of environ-

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mental conditions, naturally or artificially induced. Biological recovery includes increase in biological activity, biomass, plant cover, organic matter, and soil micro- and macroorganisms; higher fertility; better water intake and turnover; and lower evaporation and runoff--in short, improved functioning of deteriorated ecosystems. This overall process may be termed de-desertization.

Natural recovery consists in biological improvement of ecosystems via protection from man and his livestock. This protection may be total, as when an area is fenced off and people and domestic animals are not admitted (exclosure). Natural ecosystems usually respond to this treatment by allowing increased development of producers (vegetation) and then of consumers (animals). Hence a greater production of organic matter is induced which, in turn, increases biological activity in the soil, thereby improving soil structure, permeability and water intake. The entire ecosystem is thus affected. The speed of response varies greatly with local conditions. It depends on the entropy of the system, that is, the stage of deterioration of vegetation and soil, and also on the respective sizes of degraded and undegraded areas adjacent to a given zone. It depends also on vegetation and its stability and resilience, that is to say, its ability for recovery after disturbance. Stability, resilience, and entropy depend on many biological and nonbiological conditions, such as, seed availability, whether a given dominant species propagates by seeds or not, soil permeability and depth, and water storage potentialities. As a rule, biological recovery is slower when the climate is more arid, the soil shallower or more toxic, the vegetation more degraded, and the entropy higher.

Biological recovery was found to be excellent in exclosures set up in the 1950s on deep, sandy soils of Mauritania north of Adrar, under about 80 mm of average annual precipitation. The same was found in an area protected for 79 years at Nefta (southern Tunisia), where a 2-3 m high shrubby vegetation covering 30-50% of the ground sharply contrasts with the adjacent sandy area where vegetation covers 0.1% to 1% and is 1-5 cm high; the average rainfall in this area is about 80 mm and the soil is deep, with very coarse sand overlaying a gypsym pan. Similar results were observed in Kabao (southern Tripolitania, 120 mm), and in Sidi Toui (southern Tunisia, 100 mm), after 12 and 20 years respectively of protection. However, in this last site, in a 1000 hectare exclosure, recovery on shallow limestone soils was almost nil; whereas on sandy soils the recovery was considered satisfactory. Vegetation was greatly improved in biomass and ground cover in the Great Kevir area in Iran (rainfall 60 to 80 mm) after 12 years of total protection, in spite of the very poor soil (saline, gypseous, alkaline clay).

Numerous field observations on biological recovery have been made in many arid zones all over the world, but precise quantitative data on the evolution of ecosystems as a whole are generally lacking. Many

books and reports on range management show very suggestive photographs of range vegetation on both sides of a fence in protected and unprotected areas. In some cases a totally protected area might produce up to 10 times as much as the adjacent degraded areas in the same plant community. However, very few--if any--tell the detailed story of what happened to the ecosystem and how it happened.

Protection for recovery may also be partial. Domestic animals may be admitted on a temporary basis once vegetation has improved. The areas thus managed are then considered as emergency grazing reserves to be used in drought periods. There are infinite combinations between total protection, standing buffer reserves, and rotational grazing. After 2-3 years of total protection, biological recovery often results in a spectacular increase (300-500%) in primary production.

Seminatural recovery. In many cases natural recovery may be speeded up by artificial measures, such as: scarification, pitting, contour terracing, oversowing, water-spreading techniques, and fertilization. These techniques aim at helping natural vegetation to recover by increasing water and/or seed/nutrient availability; they greatly help biological recovery to take off and may save many years.

Artificial recovery. In this case, the whole ecosystem is transformed artificially by ploughing and seeding with plant species which may or may not belong to the native vegetation. These species may be sown or planted (shrubs and trees) with or without the following: irrigation or watering, fertilization, water conservation techniques, etc. Artificial recovery entails: planting of drought-resistant fodder shrubs and trees; planting of woody species for fuel; sand-dune stabilization; creation of windbreaks and shelterbelts; and reclamation of saline or alkaline land.

It has been shown that several fodder shrubs and trees may be successfully established and economically exploited for livestock in areas receiving as little as 150 mm of annual precipitation in the Mediterranean arid zone. Extensive work on this subject has been carried out in Tunisia, Israel, Iran, Chile, South Africa, the United States, Brazil (NE), Mexico, and elsewhere. The main groups of species used are salt bushes, acacias, mesquites, cactuses, saxasouls, and calligonum. However, very little has been done in this respect in the African arid zone south of the Sahara (with the exception of A. albida in Senegal). Although the native flora of the dry African tropics comprises many very palatable and nutritious species, their biology and potentials have not yet been studied.

Firewood is an acute problem in most of the arid and semi-arid zones of the developing world. Cities and villages are surrounded by ever growing areas of woodless land, extending in many places

up to a radius of 100 km or more. One of the possible answers to this situation is what has been called "village forestry" or "rural afforestation", that is, the planting of fast-growing trees in adequate sites providing good growing conditions, so as to meet the requirements without deteriorating the environment. After decades of experimentation, foresters now have a sound knowledge of wood production potentials in various arid and semi-arid zones. The main species usable for firewood are tamarix, eucalyptus (gum trees), acacias, some kinds of cypress and pine, casuarina, and others. The same species could be used as windbreaks and shelterbelts around villages, water points, irrigated perimeters, etc. The drier the climate, the more carefully the plantation sites should be selected: there is no mystery--the simple fact is that good growth requires deep, fertile soils having a good water budget and hopefully benefiting from inflowing waters or deep water tables. Such sites exist in relatively large regions in the arid zones; but the wood production potential of those areas (sometimes 10 to 15 m^3 per ha, per year) is rarely utilized.

Sand-dune stabilization techniques are well known and practised even in areas receiving less than 150 mm of rainfall (in Iran, for instance). Many of the same species may be used for this purpose that were noted for firewood. Sand-dunes have been stabilized over large areas in the arid zones of North Africa (Morocco, Tunisia, Libya), Iran, Pakistan, India, Sudan, and other countries.

Simple expedients for water conservation, such as scarifying soils having a sealed surface, may greatly increase the water intake and hence the development of natural or introduced vegetation. This would also ensure the takeoff of biological recovery. The same applies to water catchment and spreading techniques, which are not different from those used for centuries in the Near East and North Africa. [See Development Digest, April 1975, pp. 93-124.]

Saline soils and waters occur in large areas in almost all arid zones. They could be better used by utilizing salt-tolerant forage species, such as Atriplex and Kochia. Such species, which make excellent, protein-rich forage, can utilize waters having salt concentrations close to that of seawater. This has been achieved on thousands of hectares of salt land--in Tunisia, Iran, Israel, the United States, and Australia. In Australia, large areas of scalded land (i. e. eroded, saline, former agricultural land) have been reclaimed by planting saltbushes and bluebushes, especially in New South Wales, making it possible to initiate biological recovery processes.

Rational Range and Water Management

Rational livestock range management means that: 1) stocking rates are adapted to the carrying capacity of the range; 2) water

availability must be adequate to the needs corresponding to the carrying capacity in the dry season; 3) the range and the water are effectively controlled, or are owned by definite groups or by individuals, so that access to range and water is restricted to rightful claimants; 4) the range is used on a rotational pattern using differential grazing techniques, and is partitioned off by firebreaks; 5) marketing facilities are provided.

These aims may be attained in many different ways. In Syria, about 600,000 hectares of steppe land are used by grazing cooperatives where stock numbers are controlled, some rotation practiced, and fattening operations organized, involving about 300,000 sheep. In Algeria, forty grazing cooperatives of 10,000 hectares each have been established in the steppe zone, using rotation grazing, fencing, and restricted access to water. Cooperative ranches and grazing associations have been established in Kenya over large areas with various degrees of success. Grazing associations using differential grazing have also been established in Somalia. In addition, several private or state-owned ranches, with individual areas ranging from 6,000 to 100,000 hectares, have been established in the Sahel: Dahra and Doli in Senegal, Toukounous and Ekrafan in Niger (the latter has been popularized during the Sahel drought since it appeared as a green island, after burning, on satellite imagery).

Here the limiting factors, again, are not of a technical nature; the problem is social and political. It is a problem of government and organization. Pastoralists are not necessarily unwilling to accept modern technology; their adherence to it may be obtained through various incentives and motivations, and temporary food assistance to help them to accept the new living conditions. The government administration should help them organize themselves with the support of sociologists and politicians. However, one of the main limiting factors is the shortage of trained extension personnel. Range-management specialists are extremely few in Africa and in the Near and Middle East.

Good management is to use the temporary feed surpluses obtainable during rainy years. When forage production greatly exceeds livestock consumption capacity, especially in lowland depressions and natural water-spreading areas, such temporary surpluses may be mowed, converted into hay, and kept as feed reserve for the dry season. This has been done over limited areas in Tunisia, Senegal, and Niger. There is no reason why the method could not be extended. This forage is otherwise wasted by deterioration in feed value, by trampling, and finally by being blown away during the dry season.

The role of fire has to be considered in relation to management. It is estimated that bush fires annually remove 80 million tons of forage from the African dry savannah range resources, equivalent to the nine-

month diet of 25 million cattle (calculated on an intake of 6 kg dry matter per day and a consumption rate of 50%). The beneficial effects of building firebreaks on range and livestock productivity, as well as in the prevention of bush fires, are unanimously recognized.

Complementary Actions to Improve the Economy and Environmental Situations

Complementarity of pastoral and farming areas. Arid zones are bordered to the north or south by semi-arid farming areas. Two spheres of interest are in permanent competition: the farmers seek more land to crop, and the pastoralists look for feed for their cattle during the dry season. These conflicting interests could be merged in a harmonious way through diversification of crop production in the semi-aird zone by rotating field crops with forage crops, or by use of temporary pastures which, moreover, would contribute to restoring soil fertility.

Those fodder crops are: 1) In the Mediterranean zone: berseem, Persian clover, alfalfa, subclover, medic, vetch, Wimmera rye grass, sulla, forage peas, oats, barley. 2) In the tropics: legumes such as stylo, Dolichos lablab, D. biflorus, cowpea and grasses such as buffalo grass, fodder millet, blue panic. These forage crops are successfully grown between the isohyets of 400 mm and 800 mm rainfall both north and south of the tropics. Irrigated areas could make it possible to fatten and finish young and culled animals respectively from the range areas and also to build up fodder reserves for the drought periods. Again, it is a matter of planning, organization, and extension.

New sources of energy. Some countries have taken specific measures for relieving the pressure from the human population on woody species in arid zones. Algeria and Libya, for instance, make butane and propane bottle refills available at the cost price of US$3.00 per bottle of 15 kg. Purchase of the material, containers, heaters and ovens is highly subsidized. The whole system is very popular, relieving, as it does, women and children of several hours a day of painstaking effort for fuel gathering. Solar energy devices have also been designed but not popularized enough as yet, for instance, in India and in the Niger Republic. The use of solar energy for domestic heating is far from being widespread, although several systems have been developed which function perfectly and economically (Israel, India, Niger).

Government initiatives obliging large-scale consumers of fuel, such as bakers and managers of public baths, to use modern fuels instead of wood--subsidized, if need be--would also help a great deal in the fight

against desertization. Much more use could also be made of wind energy in water pumping and in providing electricity to small communities. Solar and wind energy cannot totally replace conventional forms--when the sky is overcast and the atmosphere still, one is left helpless. But they would save a good deal of conventional energy, since sunshine in arid zones is usually over 3000 hours per year and wind, if not constant, is also fairly frequent. The necessity for dual installation sharply increases the installation costs, however, and this is why these two non-conventional sources of energy are not used more.

Education and training. The number of competent ecologists and range-management specialists in Africa and the Near and Middle East is infinitesimal in relation to the needs. A recent meeting (April 1975) on the subject in Sfax, jointly organized by Unesco, FAO, and UNEP, concluded that the five countries of northwest Africa immediately need at least 200 specialists in range ecology and management, whereas the present strength of such specialists is hardly one-tenth of this figure. The governments could encourage students to take up scientific and technical jobs via the provision of scholarships, and offer good employment prospects and incentives for fieldwork. But it is likely that as long as the legal, medical, business and administrative professions enjoy superior privileges, as they usually do in many countries, scientific and technical careers will have less attraction for the young.

Ecological research, natural resources evaluation. A considerable amount of knowledge on arid zones has been built up over the past twenty to thirty years. Numerous ecological studies and surveys, as well as range, agricultural and forestry experiments have been carried out. This knowledge generally enables development projects to be implemented with confidence. Research should be carried out, however, on the following subjects:

- Definition of range types and measurement of their productivity.
- Monitoring of range trends.
- Reseeding of degraded pastures in arid zones with native and introduced species (entails applied physiological and genetic research).
- Domestication of wild fodder shrubs and trees whose richness in protein, vitamins, and trace elements are the salvation of herds during dry seasons.
- Use of native shrubs and trees as windbreaks, shelterbelts and for sand-dune stabilization. The biology and potential use of most of these highly specialized and adapted species are not known.
- More studies on surface-water resources, water harvesting conservation, and spreading techniques, and in general better use of runoff.
- Rational use of some native woodlands such as the doum palm in the Sahel, the Atriplex, Tamarix, and Betoum in the Mediterranean area.

Monitoring and project evaluation. Monitoring is concerned both with natural undeveloped areas where ecological trends ought to be identified, and if possible quantified, and with development projects for evaluating the change in the environment induced by the development process. Monitoring should use both remote sensing (aerial photographs and satellite imagery) and ground checking. Satellite imagery (of the ERTS type) collected regularly over a number of years can also yield extremely helpful information of fundamental importance in determining the size of land-management units. The variables to be monitored are mainly vegetation (composition, cover, etc.), erosion, soil loss, sedimentation, land-use and migration patterns, and human and animal populations.

Development projects also need to be periodically evaluated, preferably by outside appraisers with the help of the development agencies. This evaluation should in particular be concerned with: demographic and social changes, range conditions and trends, changes in soil (erosion, sedimentation, salinization), livestock performance, water balance and water tables, pests and diseases, as well as economic results.

Settlement of nomads and groups practicing transhumance. Nomadism and transhumance (i. e. the migration of livestock) are constraints imposed by the ecological conditions in arid zones. The climate is such that plant growth and production are too irregular in time and space to allow year-round feeding of livestock. When the forage and/or the water available are exhausted, people and herds have to move to other areas where fresh supplies are available. Hence, settlement of nomads and groups practicing transhumance entails two possible strategies: a. The feed supply for livestock in periods of scarcity is ensured, either artificially by irrigated fodder crops or by concentrates (or both), by different grazing systems, or by planning fodder shrubs and trees as feed reserves. In one way or another the assured supply obviates the necessity for migration in search of pasturage. b. Nomadic populations turn to other activities: irrigated farming, trade, handicraft, tourism, industry, etc.

The alternative to settlement is to try to control and organize nomadic activities to prevent environmental damage. The settlement of nomads is generally encouraged by governments. Attempts at organizing nomadism--such as, the provision of nomadic schools--have been successful to a certain extent, but do not seem to have been widely extended. In some countries, such as Syria and Algeria, settled grazier cooperatives have been established over fairly sizeable areas permitting internal movements of animals over large distances. Such enterprises need areas which are large enough to balance the effect of patchy rainfall on range production. This is also the case with modern range exploitation in the arid zones of the USSR, Australia, the USA and elsewhere, usually covering tens of thousands and sometimes several hundred thousand hectares.

Some Cautionary Notes

A word of caution is necessary regarding two important forms of action to combat desertization: the planting of trees in a greenbelt along the edge of the desert, and the reliance on irrigation.

Greenbelts and desertization. The establishment of greenbelts along desert margins--one of the many solutions proposed for halting further loss of productive arid land--is often advocated, and large projects are planned or are under way towards this end. The establishment of greenbelts along desert margins is based upon two main assumptions: 1) that desert creep is due to the extension of aridity from the desert into arid land, proceeding as waves of aridity propagating a more or less regular and continuous front--that is, it is an external cause generated in the desert itself; 2) that establishing a solid continuous barrier of greenbelt through tree planting would control this progressing wave of aridity by stopping dry winds, reducing erosion, increasing rainfall and reducing runoff and evaporation, and improving water intake. However, these assumptions are mere speculations, since there is no evidence in any arid zone showing that desertization is generated in the desert itself, or that greenbelts would have any effect on local or regional climate. Desertization is generated locally and on a discontinuous pattern, in arid zones, through mechanisms such as overgrazing, overcultivation, fuel gathering, hazardous water development, and hazardous irrigation projects. Desertization should therefore be tackled in the areas where it occurs by restoring the permanent plant cover so as to halt wind and water erosion.

Much research and experimentation has been devoted to the greenbelt effect over the past few decades in arid as well as in nonarid zones. The results of these experiments are very consistent, especially in arid zones.

- There is no evidence indicating that greenbelts or forest plantations can increase rainfall; and this is not surprising, since over 80% of the moisture in the atmosphere comes from the oceans and, to a small extent, from intertropical rain forests. The amount of water entering the atmosphere from arid zone greenbelts could only be infinitesimal.

- Potential evapotranspiration itself could not be affected on the regional scale either, since this is largely governed by the amount of solar energy received per surface unit. This amount depends, in turn, on latitude and cloudiness.

- The same holds for air and soil temperature. Rainfall, potential evapotranspiration, and temperatures are governed by the overall energy balance of the earth and the general circulation of the atmosphere. The effect of any forest plantation on these factors can only be negligible.

To my knowledge, all geophysicists, climatologists, ecologists and other scientists are unanimous in declaring that, in arid zones, reafforestation cannot have any significant effect on the climate of large areas. However, on a limited local scale, greenbelts--and reafforestation in general--have a strong effect on the microclimate of small areas. Experiments carried out all over the world show that windbreaks and shelterbelts substantially reduce wind speed at a distance of 2 to 5 times the height of trees windward, and 20 to 30 times that height leeward. At 10 times that distance windward, and 100 times leeward, however, the effect is nil or negligible. The width and the length of the belts have practically no effect on their protective action. Inside the belt itself, however, there is a marked protective effect in reducing wind speed, and hence the energy flow and actual evapotranspiration; reducing wind and water erosion; reducing runoff; reducing soil temperature; and increasing the organic matter content in the soil and hence improving soil structure, water intake, efficiency and biological activity--that is, increasing the overall fertility, productivity and turnover of the ecosystem.

Since greenbelts cannot have a significant effect on regional climatic conditions, it is hard to see how they could be useful in combatting desert creep. Comprehensive reafforestation of man-made deserts or of areas threatened by desertization is, for many reasons, simply unrealistic and unthinkable. The cost of reafforestation in arid zones is of the order of magnitude of $100 to $200 per hectare at the minimum (except in some very special cases where direct sowing is possible). Assuming that the areas threatened by desertization (between the 100 and 300 mm isohyets) in Africa, the Near and the Middle East are at least of the order of magnitude of 50 to 100 million hectares, the minimum investment necessary would be between 5 and 20 billion dollars for a maximum return of 5 to 10 dollars per hectare per year. Such reafforestation implies total protection from grazing and other present uses for a period of 10 to 20 years. It also raises the question of what alternatives for a living can be offered to the millions of people living in these areas.

Reafforestation has been successful in arid zones and is perfectly feasible under certain specific conditions--on deep sandy soils, along the stream network, on sand dunes, in depressions benefiting from runoff or in those having a water table. However, reafforestation has generally failed on the shallow soils which cover most of the arid zones for the very simple reason that such soils cannot store enough water to meet the transpiration requirement of trees. A minimum of about 500 kg of water is needed to produce 1 kg of dry matter. Therefore, in order to produce a minimum quantity of 1000 kg of dry matter per hectare, the soils should be able to store at least 100 mm of water (assuming a loss of 50% by direct evaporation, runoff and drainage) during the short rainy periods. Most arid-zone soils do not have this

storage capability, and therefore are not suitable for reafforestation or the establishment of greenbelts. Moreover, in some arid zones like the Sahel, where environmental conditions are particularly harsh (9 to 10 months of dry season every year, air moisture below 30% for several months), all reafforestation trials have so far failed wherever the rainfall is below 400 mm.

Thus, greenbelts do not seem to be a realistic overall solution in halting desert creep. The best way to restore desertized areas to productivity is to ensure adequate protection of soil surface from wind and water erosion and to promote biological recovery. Greenbelts would be extremely useful in protecting irrigated areas, villages, roads, reservoirs, etc. ; but planting solid strips of trees along desert margins without subsequent management organization is a myth which is doomed to costly failure.

Irrigation. In most cases arid zones exhibit two totally different types of agricultural exploitation, irrigated farming on the one hand, and extensive pastoralism on the other. These two systems could and should be complementary: the extensive herding serving for breeding purposes and the irrigated farms acting as forage producers and allowing fattening/finishing operations. Such coordination is technically workable and economically feasible; it is a matter of organization. This type of complementarity is practiced over about 20 stock-raising cooperatives in the Syrian steppe and involves about 300,000 sheep. It is also enforced on huge areas of the Karakul breeding states of Uzbekistan and Turkmenistan in the USSR. The system has been working on a limited surface of 30 hectares of irrigated forage and 8000 hectares of steppe in the Tamidt station of southern Algeria (200 mm) for over 30 years. The advantage from the standpoint of fighting desertization is obvious: part of the herd is removed from the natural pasture, thus reducing pressure on rangelands and allowing them to regenerate.

Irrigation involves at present less than 4% of arid land, and it may perhaps reach the figure of 9% in the remote future. Be that as it may, 90% of arid land will never benefit from irrigation and will have to be reclaimed by other methods. On the other hand, irrigation programs have significantly contributed to desertization over large areas in North Africa, Egypt, Syria, Iraq, Iran, Pakistan, and India through salinization and alkalinization resulting from faulty technology. It is suspected that the same mistakes caused the decline of some early irrigation-based civilizations in the Euphrates-Tigris valleys. For irrigation projects, both large and small, in arid and semiarid areas, a number of hazards are particularly critical. One is salinization of the irrigated soils, as mentioned above. Another kind of hazard is sediment deposition in reservoir and irrigation channels, and a third is changes in water table which might be disastrous to agriculture.

There are also negative effects upon public health. Introducing irrigation into an arid region increases the density of population and with the probability of increased incidence of disease, mainly due to inadequate arrangements for disposal of human excreta. From this cause arise bacterial infections producing bacillary dysentery and cholera; protozoal infections producing amoebic dysentery; infections by parasitic worms including Ascaris (round worm), Ancylostoma (hookworm) and Schistosoma, the vector of bilharzia. A great educational and administrative effort is needed to convince people that these diseases can be controlled by improved sanitation and are not a necessary consequence of irrigation.

Conclusions

The remedies for desertization are numerous and interdependent. Technically, desertization can be halted; there is no question about it, and many desertized areas can be restored to production. However, the cure can only be administered if there is a strong political will and the power to do so (which in turn presupposes political stability), since the measures which need to be adopted closely interfere with the daily life of the population concerned. Such interference may consist in population control, transfer to other areas or activities, enforced emigration, education, and in any case control of land and water use. All these are usually very touchy political issues that many governments are reluctant to tackle. The example of Iran--where about 10 million hectares of protected arid rangelands are steadily improving for wildlife or sheep-raising and where three million hectares of dunes have been stabilized and are progressively being brought to production--shows clearly that desertization can definitely be halted if the decision-makers, jointly with those having political and economical power, really so wish.

[Extracted from Chapters 9 and 11 of Can Desert Encroachment be Stopped?, Ecological Bulletin No. 4, pp. 189-200, 217-21, 204. Published by the Swedish Natural Science Research Council, Stockholm, Sweden, 1976.]

Sudan Challenges the Sand Dragon

Jon Tinker

[In the Sudan the desert is advancing and formerly productive areas have become wasteland. Countering actions have begun to be taken by the government in a number of pilot projects described below.]

Ten days ago, together with a score of other environment journalists from all over the world, I sat under the palm trees and listened to the elders of El Beshiri, a small oasis in central Sudan. El Beshiri's problems are summed up in one word: desertification. Kordofan, traditionally the richest agricultural province in the Sudan, now stands on the brink of disaster. Over a 12 year period, the productivity of farmland has fallen: yields of maize in Kordofan in 1973 were only 46 percent of that in 1961, while yields of sorghum were down to 40 percent. Yields of sesame were down to 23 percent of 1961 figures, and groundnuts 22 percent. And millet, one of the staple foods of the area, produced in 1973 only 13 percent of the yield per hectare which it gave in 1961. Four years later, the situation is worse. Further, these average yields per hectare do not include the big acreages which have had to be abandoned.

To a severe deterioration of the agricultural base must be added the degradation of the rangelands, the pasture for the herds of nomadic tribesmen who supply 90 percent of Sudan's livestock. Although the 1968-73 drought reduced numbers of cattle, it did not greatly

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affect goats, sheep, and camels. Kordofan's livestock is estimated to have increased nearly sixfold since 1957--far beyond the carrying capacity of the rangeland--and there is a further 10 percent increase every year. When the next drought comes (in the Sahel droughts are a matter of when, not if) more of the Sudan's livestock and agricultural production may disappear. Over the whole breadth of the Sudan, desert conditions are advancing southwards at 5-10 kilometers per year.

These facts and figures are well known to a handful of Sudanese politicians, scientists, and administrators (which reputedly includes President Nimeiri himself); a determination to take urgent action is growing. But the ignorance of many professional agriculturalists and economists and of narrowly specialized scientists may represent a powerful obstacle against appropriate action. "What limit should we place on livestock numbers?" responded a Kordofan livestock official to a question. "We don't want any limit at all. We want to increase our animal population, to supply our traditional markets in Arabia and Egypt, and to export meat to Europe." The Food and Agriculture Organization (FAO) and the Kuwaiti- and Saudi-backed Arab Fund for Economic and Social Development have hopes that the Sudan will become the breadbasket of the Middle East, a major world exporter of grain, to supply 58 percent of the Arab world's food by 1980. And several grand new schemes are being planned: the 300,000 feddan Rahad project (1 feddan = 1.038 acres = 0.42 hectares), financed by the World Bank, the US and the Arabs; Prince Mohammed el Feisal's 500,000 feddan ranch at Damazin; the 500,000 feddan Setit scheme on the Atbara river; Lonrho's 80,000 feddan Kenana sugar plantation. These will all be irrigated from the Nile or its tributaries, and are all modelled on the success of the Gezira project which is, with over 2,100,000 feddans, the largest farm in the world.

It is, however, by no means certain that the Gezira is a reliable model. Certainly, the 100,000 tenant farmers who work the Gezira have a reasonable standard of living, and the vast state-run farm does produce high yields of cotton, sorghum, wheat, groundnuts and other crops. In half the Gezira, the Managil Extension area which came into cultivation around 1960, the land is cropped in a three year rotation: cotton, wheat, and sorghum/groundnuts. But in the Gezira Main area, which has been irrigated and farmed since the 1920s, the soil has become so exhausted that every fourth year it must be left fallow.

Gum Arabic Cultivation

To understand how desertification is undermining the very survival of the Sahel, it is worth looking in detail at one ecosystem: the gum arabic zone of Kordofan. After cotton, gum arabic is Sudan's largest export, worth from $14 million to $26 million in recent years. Sudan

produces over 90 percent of the world's gum arabic; there is no synthetic substitute for it in pharmaceuticals, glues, jellies, sweets, and soft drinks. The gum is exuded from Acacia senegal, a low thorn bush, forming semi-solidified lumps ranging in size from a marble to a golf ball, after the bark has been cut with a knife. Acacia senegal, or hashab as it is known in Arabic, grows between the steppe and the savannah, in the 250-450 mm rainfall belt. The Acacia-grassland ecosystem is the climax vegetation in this area, with the trees forming an open canopy. As in a tropical rainforest, the soil is extremely poor and the nutrients and moisture are held overwhelmingly in the vegetation rather than in the soil. As the trees die, their prickly fallen branches shelter from grazing some taller grasses and herbs. In the dry season this growth is liable to catch fire, allowing open grassland to appear until Acacia seedlings once again establish themselves.

In Kordofan, traditional agriculture is an adaptation of this natural fire-red scrub-grassland-scrub cycle. First, the Acacia scrub is cleared by burning; sesame, millet, sorghum, maize and other crops are grown in the sandy soil for four to 10 years. The soil is by now exhausted, and the fields are abandoned to fallow. Weeds, grass and eventually acacia seedlings invade the land; and after about eight years the young hashabs are ready for tapping. After another six to 10 years, the thorn trees start to die; they are felled, burned, and the land cleared once again. Each farmer has some gum orchards for a cash crop, and some arable fields for his subsistence crops. Several crops are usually grown in close proximity, either in small separate patches or intercropped in adjacent rows. This mosaic offers the best insurance against the unpredictable rainfall, as well as protection against pests: Kordofan seems rarely to suffer the depredations of weaver birds (Quelea) which are such a plague in the monocultures of Sudan.

This ecologically-balanced cycle of gum gardens, fire, grain crops, and fallow is now breaking down, the 1968-73 drought having in many areas given it the coup de grace. Under pressure of a growing population, the cultivation period is extended by several years, and the soil becomes too impoverished to recover. Overgrazing in the fallow period prevents the establishment of seedlings. Gum trees are lopped for firewood. More and more widely, Acacia senegal no longer returns after the fallow, but is replaced by non-gum-producing scrub: the thorns Acacia tortilis and A. raddiana, and the broom-like shrub Leptadaenia pyrotechnica. And without the gum to harvest for cash, farmers must repeatedly replant their subsistence crops until the land becomes useless sand.

Not far from El Beshiri, 15 km. or so south of Mazroub, is an area that was once gum gardens. Today, 90 percent of the Acacia senegal

trees lie dead on the ground, killed in the 1968-73 drought. But if lack of water was the proximate factor in their deaths, the ultimate factors were the degeneration of the soil through over-cultivation, the deterioration and destruction of the grass cover by overgrazing, and direct browsing of the trees by animals unable to find more palatable food. Come drought, neither grass nor soil retained enough moisture for the trees to survive.

There are, of course, many other aspects to the desertification process, even in this same gum arabic belt, than the destruction of the gum groves. Improved veterinary care and the digging of pumped wells and surface reservoirs are the two main causes of the livestock explosion. For a kilometer around the Mazroub watering area, for example, there is not a blade of grass to be seen, only a few scattered tree stumps and the odd surviving thorn tree. Even after 5 km, ground vegetation is only established under the thorny protection of dead trees. From the air, each village with a watering point can be seen to create an irregular area of sand around it, extending in some directions for 10 km or more, as well as reaching for several hundred meters to either side of the tracks leading from the nomads' waterholes.

The energy crisis makes its own contribution to desertification, by increasing the demand for wood and charcoal. Around the larger towns, the charcoal burners and woodcutters scour the countryside for 40 km and more, often chopping wood even from living gum arabic trees. However, the smaller villages do not seem to suffer any fuel shortage, as dead wood lies on the ground within a couple of kilometers of some of them.

Overgrazing, overcultivation, excessive burning and firewood collecting together produce the symptoms of desertification: mobile dunes which engulf oases and farmland, bare sand in which not a blade of grass can grow, agriculture which is no longer sustainable, falling water levels in the wells, flash floods, the nomads and the agriculturalists moving further south into the savannah, clashes and deaths as grazing rights conflict and herdsmen come up against farmers. At risk are the marginal peoples of the marginal lands.

Action Programs

The Sudanese have recognized the problem earlier than most. What are they doing about it? A number of imaginative and practicable techniques are already in use. One such is waterpoint management: the opening or closing of wells and boreholes. The Hawazma tribe, for example, migrate between a wet season grazing area near El Obeid in Kordofan to a dry season grazing area at Bhr Elarab 400 km

away. Along most of their route, from waterpoint to waterpoint, a mile-wide deterioration of the range can be seen. The Hawazma were persuaded to shift out of this degraded corridor when the government closed the usual waterpoints and opened others a few miles off their usual route, so that the nomads followed a parallel course and allowed the damaged range to recover.

Another technique, this time to limit the effect of large-scale fires, is the construction of firebreaks, forming a criss-cross network between watering points. First, two parallel swathes, 2-5 meters wide and 80 meters apart, are plowed across the countryside. Then the strip between the plowed areas is burned. Since 1958, Sudan has established 5100 km of firelines, protecting 20 percent of the vulnerable rangeland.

A third method, this time to stabilize shifting dunes, has already saved El Beshiri oasis from extinction. In 1970, 650 feddans (one square mile) of land in the dune's path were enclosed by a stockproof fence, stabilized mechanically by planting rows of dead Leptadaenia brushwood, and afforested with 300,000 seedlings of Acacia senegal, mesquite, and other trees from a local nursery. Although there has been some illicit grazing, a good sward has developed, the trees are thriving and the dune is halted. In 1970 the villagers were hostile to the project largely because it involved enclosing common grazing land. But when in 1973 the dune was clearly no longer mobile, El Beshiri changed its mind. The scheme's popularity is evidenced by the deputations from neighbouring oases threatened by dunes, which came to our meeting in El Bashiri to ask the foreign journalist to make the government plant trees in their villages, too. As a pilot project, El Beshiri has not been cheap: it has cost $114,000 over six years. The most expensive item is fencing; any government wishing to help the Sudanese could do worse than build them a barbed wire factory.

A fourth technique is planting shelter belts around town perimeters. At El Obeid, the provincial city of North Kordofan, trampling, grazing and woodcutting has since the 1940s surrounded the town with a vast area of open sand. In 1952-54 nine forest areas were fenced off, together encircling the town, but each separated from the next by 200-meter corridors for the nomad herds to pass through. Old tree stumps started to sprout, the grass reseeded itself, and new gum trees were planted.

Today, although two of the nine forests have been felled to make way for an airport and new housing, the remainder are clearly successful. Local people are given licences to collect the gum arabic, and it is planned to fell the trees in rotation, and lease the land for farming before fallowing it and returning it to acacia scrub. Unfortunately, the fencing is now old and broken, and illegal grazing pressure is probably

near the point at which it will do permanent damage. The cost of refencing, though, with angle iron and barbed wire, will be well over $250,000. Wooden fence-posts resistant to termites, or a quick-growing camelproof live hedge, should be major targets of Sahel research.

Out of these pilot projects, and with the advice of the UN Environment Program, the UN Development Program and FAO, the Sudanese have developed a modest $26 million desert encroachment control and rehabilitation programme (DECARP), involving the establishment of grazing cooperatives, range seeding, firelines, small-scale irrigation, town perimeter afforestation, sand dune stabilization, and shelterbelt establishment (especially where moving dunes are invading the precious alluvial strip along the Nile). Instead of the DECARP scheme simply being imposed from Khartoum, there are to be five provincial centers to provide demonstrations, technical assistance, seed, and equipment for do-it-yourself programs.

Sudan today stands at an agricultural and development crossroads. In one direction lie massive dams and grandiose canals, million-feddan irrigation projects and cash crops, dreams of Arab breadbaskets. The other way is less dramatic, involving halting and then turning back the spread of desert conditions, the stimulation of peasant farming, the development of nomadic livestock production. One direction will break up traditional societies and use their people as the raw material for ambitious blueprints. The other will build on transhumance and nomadism, shifting cultivation and subsistence farming, raising the living standards of the people without destroying their social fabric.

Of course, Sudan could go both ways at once. The problem with schemes like Rahad and Kenana and Damazin is not that they will go wrong (they may go right), but that they will divert Sudan's attention from DECARP and similar projects, without which the country will face disaster. Minister Wadie Habashi (who is in charge of the National Research Council) puts it like this: "Development so far may have been economically sound, but socially and environmentally it has perhaps not been so satisfactory. There has been ignorance by all of us--by those of us, for example, who have placed water points haphazardly, with not enough care to prevent overgrazing and destruction of natural resources. We must take action now against desert creep."

[Extracted from New Scientist, of 24 February, 1977, pp. 448-450. IPC Magazine Ltd, London, England. Copyright © Jon Tinker.]

The Negev: A Desert Reclaimed

Joel Schechter, Editor

[The Negev desert in southern Israel has been the locale for innovative methods of introducing crop growing and livestock raising in a hostile environment. This article outlines the ways in which scarce water supplies have been mobilized and applied, e. g. in trickle irrigation, and the kinds of plants and animals that have been found suitable. (See also Development Digest of April 1975, pp. 93-124.)]

The desert area of the Negev covers the southern half of Israel, and has an irregular rainfall of under 250 mm a year average, sometimes as low as 25 mm. Its climate varies with differences in topography, particularly in the Rift Valley where altitudes suddenly drop from 100 m above sea level to 400 m below. Soils vary from deep loessal deposits in the higher rainfall areas to bare, rocky surfaces in the south. The process of desertification was largely man-induced; there has been little climatic change over the centuries. Overgrazing and the overuse of vegetation for fuel and building materials denuded the hillsides and exposed the soil to erosion. Neglect of the fragile terracing and dams of earlier years removed the barriers to soil erosion and degradation, and the process of desertification intensified.

The recovery from the desert was at first a question of reconstructing conditions capable of supporting agricultural development. It involved measures for soil conservation, bringing water to the south from the major water resources in the north of the country, developing techniques of irrigation, finding ways of utilizing local brackish water resources, and organizing agricultural management systems adapted to the desert

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conditions. Many agricultural settlements have been established. The inhabitants were assisted by financial aid, including drought compensation and water subsidies for irrigation, as part of an incentive program to encourage farmers to attain long-range sustained productivity. The population of the region has increased from 14,000 in 1948 to some 250,000 in 1975; agricultural settlements were the first to bring new life to the desert, but today over 80% of this population live in urban settlements. Later stages of regeneration of settlement in the Negev, and possibilities for the future, have now been linked to the potential for industrial development.

Water - A Major Factor in Recovery

Water Sources. The obvious direction for recovery of arid areas is the supply of additional water and more efficient use of already available supplies. Most precipitation occurs in the northern areas of Israel and it is there that the national water reservoirs (both surface and subterranean) exist. All water in Israel is derived from rainfall, which occurs only during the winter season. Most of this precipitation simply runs off to the Mediterranean or the Dead Sea, or evaporates from the soil. The remainder seeps into underground aquifers or drains into Lake Kinneret (Sea of Galilee) and is stored (minus evaporation loss) until needed, which is generally during the long, dry summer season. These storage basins are quite far from the arid Negev, which has no reservoirs of good quality water. They are also situated at low elevations, hence water must be pumped up several hundred meters in order to reach those elevations where it can be used for agricultural purposes. The costs of pumping and of drilling wells make Israel's water supply costly even before it is transported to the fields.

Israel utilizes today over 95% of its potential water supply. This amounts to only about 1,600 million cubic meters per year, which is the annual rate of replenishment of all water sources. In years of poor rainfall, aquifers are not sufficiently replenished and this can lead to difficulties in supplying the needs of agriculture. The projected water demands for the country indicate a need for perhaps 2000 million cubic meters by 1985. It is intended to make up this difference by the treatment and re-use of minicipal and industrial waste effluents, by the use of saline water resources and possibly by desalination of ocean water.

In order to convey surplus water potential from the north to areas which lacked it, and to facilitate coordinated control of water sources, several regional schemes with relatively small pipelines were carried out in the 1950s. These schemes were integrated by the construction of the large National Water Carrier in the mid-sixties. The National

Water Carrier, which issues from Lake Kinneret, now carries over 300 million cu. meters of water per year; it is conveyed through a network of canals, reservoirs, pipes and pumping stations to the agricultural areas of the south, where it is used as a basis for settlement and revitalization of this formerly inhospitable, arid region. The high pumping costs, long-distance transportation of water, lack of sufficient reservoirs, and general overall water shortage have forced Israel to relate to water as a scarce and precious natural resource.

The legal status of water. Israel's Water Law of 1959 states that "water sources are public property, controlled by the State, and devoted to the needs of its residents and the country's development. A person's right in land does not grant him rights in water sources located on that land or passing through it." The Government has set up a system to allocate water quotas to various regions and municipalities, and to individual farmers. This law constitutes the basis for inter-regional transport of water to the arid Negev.

The Water Law also provided for an "equalizing" fund to regulate the price of water in such a way as to reduce the differences in water charges among the various consumers in order to attain an equalitarian division of this vital resource. At the same time, it imposed upon the Government the responsibility of administering a complex economic and social organization, whose ramifications extend into almost every aspect of the Israeli economy, under the provision that "every person is entitled to receive and use water subject to the provisions of the law." The advantages of the law can be summarized: a) It allows more equalitarian distribution of water among farmers. b) It has led to the development of a rational overall water plan. c) It permits encouragement of regional specialization, exploiting local differences of climate and soil. d) It acts as a tool for regulation of agricultural production to meet the demands of the local and export markets. e) The quota system limiting the amount of water to each farmer is an incentive for efficient use of water. Some disadvantages are: a) The subsidized pricing system sometimes permits the use of expensive water for uneconomic crops; and individual water rights may inhibit growth of large farm units to gain economies of scale. b) The water quota system does not react rapidly enough to changes in market demands or new developments in farm technology. c) The administrative system is sensitive to changing political outlook and to organized pressure groups.

Technology of Water Use

Because water is the limiting factor for agricultural production in arid zones, every effort has been made to exploit each unit of costly water transported from the North as effectively as possible. The use of advanced agricultural techniques and the development of technologi-

cal innovations have contributed, more than any other factor, to the high productivity of Israeli agriculture. Income from agricultural produce is measured per unit of water input as well as per unit of land. Decreasing the amount of water used per unit of production not only reduces production costs and raises the farmer's profit but also frees water for additional production. In the framework of a tight water quota the farmer has ample incentive to utilize his allocation as productively as possible.

High capital investments have characterized Israeli agricultural technology. The major system of irrigation used is sprinkling. This technique gives good uniformity in water distribution and allows the farmer excellent control of the quantity of water to be delivered to any particular area. Water is brought to the fields in a closed system of pipes, reducing losses by evaporation or leakage. This system is relatively simple to operate, even by inexperienced farmers, and requires less labor than surface-irrigation methods. In reality, the capital investment required for a sprinkler irrigation system is little more than for surface-irrigated fields if those fields are properly graded and levelled.

In the last few years the use of drip or trickle irrigation systems, an original Israeli development, has been expanded. Plastic tubes with trickler holes inserted at desired intervals are placed in the field, so that water emerges only next to designated plants or trees. The great advantage of this system is reduced evaporation, since only a small area of the soil is wetted and the water is not sprayed into the air. Here too, excellent control of water quantities delivered to the field is attained. And fertilizers are usually injected directly into the irrigation water, resulting both in their effective utilization and in reduced application costs. The tricklers are run almost continuously so that the soil root volume is continuously wetted. Prevention of the wetting and drying cycles in the soil has resulted in exceptionally high yields per unit of water and of surface. National figures on water use in agriculture from 1948/49 to 1973/74 indicate that water consumption rose from 257 to 1150 million cubic meters while the area under irrigation increased from 30,000 to 180,000 hectares, so that water use per hectare decreased by 25% at the same time that productivity per hectare was rising substantially.

It was understood that installing a modern irrigation system affording good distribution and regulation of water must be accompanied by other technological inputs in order to optimize agricultural yields. This has meant the development of a highly intensive farming system using the most modern cultivation methods as well as an efficient extension service, research, marketing facilities, etc. With these methods Israel has increased its total agricultural production more than ten fold during the past 25 years. Many crops have shown

increased efficiency with water use--for example, cotton has shown a 50% increase in yield per kilogram of water over a recent period of 6 years.

Run-off Water. Some of the rains in the Negev occur as torrential downpours of high intensity, usually over a very restricted area. A large amount of this precipitation runs off the hills and slopes and collects in the wadis, resulting in floods sometimes of several days duration, causing a loss of potential irrigation water. The Ministry of Agriculture has made long-term loans available to settlements for the building of dams to catch these waters and use them for irrigation purposes. The major problem is that while rains occur only in winter, irrigation water is needed mostly in summer. The storage of water from winter to summer results in substantial losses due to evaporation, leakage and infiltration. One solution was to use the water immediately for supplementary irrigation of rain-fed winter grain crops in areas of the Negev with marginal rainfall. For example, in a region of 300 mm. rainfall another 100-200 mm. of collected run-off water is applied, which will often raise yields by over 50% and ensure a grain crop even in years of abnormally low precipitation. Pumping the water to the fields as soon as possible after it has accumulated in the dam ensures minimal losses and frees the dam for collecting more water if additional floods occur during the season. Where used, this technique has resulted in average grain yields of 3.5 tons per hectare, and yields of five tons per hectare are not uncommon.

Another use of run-off water collected behind dams is to pump it to infiltration basins where the collected water will infiltrate and enrich a subterranean aquifer. This form of underground storage also reduces evaporation losses and frees the dams for additional flood collection. The water can then be pumped out of shallow wells and used for irrigation of summer crops. Obviously, this technique is limited only to those situations where natural underground storage is possible.

A further method of utilizing run-off water has been experimented with by Prof. Evenari at Avdat, in order to test techniques of ancient desert agriculture. This site represents the remains of an ancient Nabatean town whose inhabitants cultivated the low areas of the wadis about 200 B. C. - 400 A. D. These wadis are terraced, and rainwater falling on the hillsides was collected by a series of long channels, each channel bringing water to a specific area of the wadi terraces. Although the region's total annual precipitation amounts to only 100 mm., this usually includes at least one rainfall heavy enough to result in a flood that will wet the wadi soil sufficiently to yield a good crop. The Nabateans were skilled hydraulic engineers and succeeded in constructing thousands of these farms with efficient water collection and distribution systems. The Evenari team reconstructed two of

these ancient Nabatean farms and succeeded in obtaining excellent yields of grain, fruits, vegetables, pasture and other crops.

This method of runoff farming, while very effective under extremely adverse conditions, is not yet economically feasible due to the high investment costs. The same group of scientists also developed a system of individual microcatchments. In one corner of each plot a single tree or bush was planted and the plot graded so that the runoff water would accumulate around the plant itself. The optimal size of the microcatchments had to be determined experimentally for each of the various species that were tried. Depending on the plot size, it is estimated that investment costs will be in the range of $20 per hectare. Yields of 400 kg of dry matter per hectare have been obtained, which is a considerable increase over the original dry matter production in the area. A large area is now being established for wider scale experimentation.

Water Desalination. Another source of water can be obtained by desalination of inland brackish water or of ocean water. Israel has spent considerable sums for research and development in this field. The techniques experimented with include electrodialysis, reverse osmosis and ion exchange for desalination of underground brackish water, and various distillation processes for desalination of ocean water. Today there are several desalination plants operating in the Negev and the manufacture of desalination units for export has become a very lucrative industry. In general, it has been found that inland saline water rich in chlorides is best desalinated by electrodialysis methods, while water rich in sulfates responds best to reverse osmosis methods. Both methods are still much too expensive for use in agriculture, but they certainly could be used for supplying potable water to population centers at a reasonable price. Several reverse osmosis plants are now under construction in the Arava Valley to supply drinking water to the agricultural settlements there.

Brackish water irrigation can prove almost as effective as irrigation with good quality water when proper techniques are employed. However, in many areas there is a slow but gradual rise in water salinity. Water in an aquifer usually drains into a river or into the sea, carrying its salt with it, a natural process which removes the salt. However, when water is removed from the aquifer for irrigation purposes this process largely ceases; salt draining into the aquifer now accumulates and salinity rises. In some Negev aquifers salinity is rising by 3-4% per year. At some point desalination processes will have to be used to remove salt from the hydrological system, even though this is not yet necessary.

Another future use for brackish water desalination methods is for desalination of municipal and industrial effluents. This water, if properly treated, could be used again for industrial or agricultural purposes. At present a large proportion of these wastewaters is being infiltrated into the coastal aquifers. The water is purified in the process with resultant recharging of the aquifer.

It is more difficult to desalinate sea water, which is more saline than brackish water and often has a higher organic matter content which can cause fouling of desalination equipment. The use of vapor-compression methods for distilling sea water has been successful in Eilat and other settlements in the south. Again, the price of desalination is still too high for normal agricultural use but is cheap enough for municipal or for many industrial uses.

Rainfall Enhancement. Another experimental method for increasing water supply is rainfall enhancement by cloud seeding. Most clouds suitable for seeding are found in the rainier northern region of Israel and not in the Negev. However, since a large part of the Negev's irrigation water originates in Lake Tiberias in the north, increased rainfall in that area has direct significance for the Negev.

Israeli experiments were performed to investigate the possibility of increasing the water potential in 1961-67 and in 1969-75. Despite difficulties in interpretation of complex statistical data, results show that rainfall increases due to seeding were 17% in the Lake Tiberias Catchment. These experiments are continuing.

Arid-Zone Irrigation with Brackish Water

Brackish water reservoirs occur in most deserts of the world, and in the Negev desert south of the 200 mm rainfall line most of the underground aquifers are saline. All the settlements in the Arava valley use local brackish water with salt concentration between 700 and 3,000 ppm total dissolved solids (TDS) for irrigation of their out-of-season vegetable and flower crops. Most of the brackish waters in the Central and Western Negev, however, are not being fully exploited at present.

Irrigation Technology. The breakthrough in brackish water agriculture was brought about by the development of trickle irrigation. This technique, developed in Israel in the early sixties, lifted the "salt tolerance" levels of most crops and made possible the cultivation of many plant species (onions, green peppers, cucumbers, citrus) which grew poorly when irrigated with brackish water (2,000-3,000 ppm TDS) by other irrigation methods. The advantages of this irrigation system for brackish water use are as follows: a) The leaves

are not wetted with salt water, as in the sprinkle irrigation method (salts were found to penetrate leaves, causing severe burning, chlorosis and leaf distortion); b) Continuous leaching of excess salts from the root zone; c) Maintenance of very low soil matrix potential; d) Wetting of a relatively small soil surface area (as compared with sprinkler irrigation) thus creating a much higher salt leaching capacity for a given amount of water applied.

Most plants are especially sensitive to salt during the germination and establishment stages. Overcoming salinity hazards at these stages will be necessary to ensure successful yields. With the conventional methods of irrigation in the Negev, the soil is wetted prior to sowing to a depth of about 150 cm, and light irrigations are given after sowing to keep a moist soil surface for the germinating seed. However, recent experiments have shown that frequent irrigations bring about rapid accumulation of salt around the germinating seed, reducing germination, and inhibiting growth of those seedlings which do germinate. To prevent such accumulation salts must be leached continuously out of this zone. This has been achieved by changing the irrigation practice: no pre-irrigation is given, but very large quantities of water are applied during sowing-to-emergence period, exploiting the water which was "saved" from pre-irrigation together with the water normally applied at post-sowing irrigation. Results achieved with this method are very favorable compared with those of the conventional method.

The quantity of salt removed by plants is very small in comparison to amount introduced via the irrigation water. In areas of moderate to heavy rainfall (over 300 mm) the accumulated salts are leached by rain. In more arid areas, water in excess of evapotranspiration must be added to prevent year-to-year salt accumulation. This requirement is a function of the salt concentration in the irrigation water, the irrigation frequency, and the salt tolerance of the cultivated crop.

Salt tolerance depends on many factors, i.e., plant variety, atmospheric conditions, soil temperature and aeration. Salt-sensitive plants require a more rigid control of salt in their root zone during the growth season and more leaching water than salt-resistant species. Tomatoes, for example, are irrigated every seven days with 25 to 35% water in excess of evapotranspiration; cotton, however, is watered every two weeks with quantities only slightly exceeding evapotranspiration.

Selection of salt resistant species and varieties. Plants differ greatly in their resistance to salt in the root zone. Where possible, salt resistant species such as cotton, wheat, and sugar beets are being used, yields of which are usually unaffected by the salt concen-

tration in the brackish water of the Central and Northern Negev (2,500 ppm TDS) provided irrigation, drainage and fertilization regimes are correct. There are genetic variations in resistance to salt within many species. Selection of the most salt-resistant varieties is most important in those species which are only moderately salt-resistant. Fodder plants are more resistant to salt than other field crops.

The introduction and selection of salt-and drought-resistant species for desert growing is being carried out at Ben-Gurion University in Beersheba. Suitable seeds are collected from deserts all over the world and sown in the nursery. Those which germinate and grow well for at least one season are transferred to experimental fields. Plants which grow successfully in the field are selected for repropagation in the nursery. New seedlings are distributed to various locations, representing different climatic regions, and their progress is recorded. Plants can now be recommended for all regions of the Negev. A garden has been planted at Sodom on the shores of the Dead Sea, irrigated with local underground saline water, and landscaping is being developed in the town of Eilat and along the Red Sea shore under similar irrigation.

Agricultural Technology in the Semi-Arid Zone

Farmers in Israel's arid and semi-arid zone have a wide range of management options open to them because of the availability of external inputs. These include fuel, machinery, fertilizer, plant protection chemicals and (sometimes) water. The type of farming system adopted and its economic viability are determined, as everywhere, not only by the constraints imposed by biological and environmental conditions but also by economic and social considerations.

Crop Cultivars. The main crops cultivated in semi-arid regions of Israel include wheat, barley, vetch for hay, cotton and sorghum. Other crops cultivated on a much smaller scale include watermelons, oats, sunflowers and safflower. As a result of an extensive wheat introduction and breeding program there are about a dozen wheat cultivars in current use. Barley varieties available are much fewer because of the decline in barley culture over the past fifteen years, due to higher wheat prices coupled with the introduction of new high-yielding wheat varieties. The actual area of hay has dropped drastically over the past decade and the dominant remaining species used is a locally bred vetch variety ("Assor"). A considerable part of the vetch in the semi-arid region is grown for seed.

Originally, all local wheats were hard wheats (Triticum durum), the main cultivars being Noursi and Ettit. In 1957-58, the new Mexican dwarf cultivars were introduced. These were high-yielding but had poor baking quality. In 1962/63, new dwarf and semi-dwarf cultivars were introduced, also with high yielding potential but with better baking quality. Subsequent yields (with supplementary irrigation) reached 7,000 kgs per ha. The dwarf and semi-dwarf cultivars rapidly replaced the previously dominant variety (Florence/Aurore) which was not sown at all after 1973. Wheat breeding then took on added momentum and many new local dwarf and especially semi-dwarf cultivars were developed.

In the semi-arid region sorghum is sown only when sufficient soil moisture has been stored from the winter rains. The area is thus variable and confined mainly to the northern margins of the semi-arid zone. In years when winter rains are less than 350 mm, farmers sometimes sow sorghum instead of leaving the land fallow. Most of the remaining crops are summer growing species. As a result, they can produce economic yields only in relatively good years, or with supplementary irrigation. These are mainly "opportunistic" crops in the sense that they are sown as an alternative to leaving the land fallow on a wheat rotation, whenever soil moisture at sowing time is sufficient to ensure a crop. Among that group sunflowers (local dwarf CV) have been prominent. Safflower (Carthamus tinctorious) is also grown on a scale that varies with local market conditions. Dryland cotton is becoming more common as cotton prices continue to rise. Watermelons are occasionally grown too. [Detailed description of fertilization and other practices omitted.]

Livestock Husbandry. Livestock husbandry systems in the semi-arid region of Israel can be divided into the following groups:

a) Intensive dairy farming, based largely on imported concentrate feed, and supplemented with locally-grown hay and a small amount of irrigated green forage. Where available, residues of other agricultural crops are also used, including peanut hay, low-grade vegetables, potatoes and sugar beet tops. This system is managed as an oasis, creating its own conditions, and virtually independent of the surrounding semi-arid conditions. The main adaptation to the environment is effected through the locally-bred animals (Israeli-Friesian) that produce well in a hot climate and through the building installations that are usually light and open, as very little protection from the elements is necessary.

b) Intensive sheep-farming, which is divided in two main directions: milk production for the cheese industry, based on improved locally-bred Awassi fat-tail sheep; and mutton production, based on the imported German Meat Merino. Both systems rely heavily on imported concen-

trate feed, the mutton-raising system almost wholly so. The milk sheep utilize green winter pasture when this is available, no further than two or three kilometers from the milking shed. There is also some utilization of stubble fields in the summer. Recent price restrictions on sheep milk have made the branch less profitable than previously. This, coupled with the fact that trained manpower to manage such intensive systems is becoming increasingly scarce as better paying and less demanding jobs become available, has resulted in many herds being disbanded.

c) Extensive beef raising, based on a mother herd, maintained mainly on range and stubble fields and on a feed lot for fattening young stock after weaning until marketing. As there is very little pasture that is sown for the use of the beef herd, its viability depends on the extent of range-land available for winter, spring and early summer grazing. As such land is limited in the main small-grain region, but is more common in the east and northern Negev, such herds are found on the fringes of the cultivated region. Stubble lands for summer grazing are available in excess and as a result are not fully utilized by the beef herds. These stubbles are hired out to Bedouin herds or burnt.

The carrying capacity of the hill ranges in the south is between 5 to 8 ha per cow. The range is generally fenced into paddocks of 100 to 300 ha each. The grazing system is a loose rotation movement of cattle from one paddock to another dependent on the judgement of the herd manager. Supplementary feeding of the mother herd is practiced in summer and especially in fall. The summer supplementation is often limited to chicken droppings which are fed at the rate of 2-5 kgs per cow per day, which is cheaper than the more common oilcake protein supplement. In fall and especially after the first rains when the pasture is particularly poor, supplementation is increased by feeding either barley or concentrate, up to 4 kgs per cow per day.

The beef herds are maintained on rangeland with an agerage of more than 200 mm rainfall. Beef production is then between 20 and 40 kgs per ha of rangeland (with the supplementary feed detailed above and about 4 to 5 months of stubble grazing). In the fifties and early sixties, some areas of pasture shrubs, mainly Atriplex halimus, were planted. These became established and provided some green summer feed for the beef herds. But the benefit did not appear to warrant the cost of establishing these shrubs and the practice has been discontinued.

d) Bedouin herds, mainly composed of sheep and goats, are based on nomadism. These herds are also part of the new cropping system even though they belong to separate communities. Winter grazing is mainly in the hill and fallow pasture in the southern and central, more arid parts of the region, and summer grazing is on grain stubble in the main cropping region. The stubble grazing is generally leased to herd owners on a per head, or more generally, per unit area basis.

The integration of livestock and cropping in the new agricultural systems of the semi-arid zone in Israel demands an intensive grazing system that will provide an attractive alternative to the wheat-fallow rotation. This is possible only if the return per unit area from pasture in a ley rotation is of the same order of magnitude as that from the crop-land. Experimental work at Migda does point to possibilities in that direction. Sheep maintained at a stock density of one ewe plus lamb per ha could give a greater return than wheat, provided they could be maintained only on pasture, and it has been demonstrated that this is possible in the green season, even in a dry year. Lamb yields should also be high so as to cover the heavy investments in livestock. Fecund breeds (Merino; Finnish land race crosses) or hormone-induced twinning in the local adapted breeds could provide above 1.6 lambs per ewe per year. Mutton production should be greater than 300 kgs per ha. Such an intensive pastoral system would considerably improve the productivity and profitability of the present system, and may be a viable system for the future.

Greenhouse Agriculture. In deserts which are situated near the sea, water need not be a limiting factor, since sea water could, in theory, be desalinated and transferred inland for irrigation purposes. This is feasible, however, only if the return for the crops irrigated is high enough to cover the high costs of desalination and/or the water consumption by the plants is drastically reduced. It is possible that these two conditions could be met by development of greenhouse agriculture based on out-of-season crops.

Greenhouse agriculture offers the following advantages: 1. It uses the desert's advantages, namely high radiation, clear winter days and, in locations close to the sea, relatively warm winter nights. 2. The return per unit of water applied is three to four times higher than the return for conventional agriculture. 3. It requires a high degree of specialization, so that in the case of Israel it permits the exploitation of local farmers' skills and of advanced farming services. 4. It provides the opportunity for controlling the environment of plants. If greenhouses could be sealed during the daylight hours without resultant excess overheating, then evapotranspiration losses of irrigation water would be markedly reduced.

The first greenhouse in the Western Negev was constructed in 1971 and there are now 40 acres, mostly devoted to tomato cultivation. Each settler has 0.2 hectare of greenhouses in which tomatoes are cultivated. After two years of settlement, the more successful farmers have attained yields of 250 tons per hectare. New settlements in the Western Negev based on the greenhouse industry are planned.

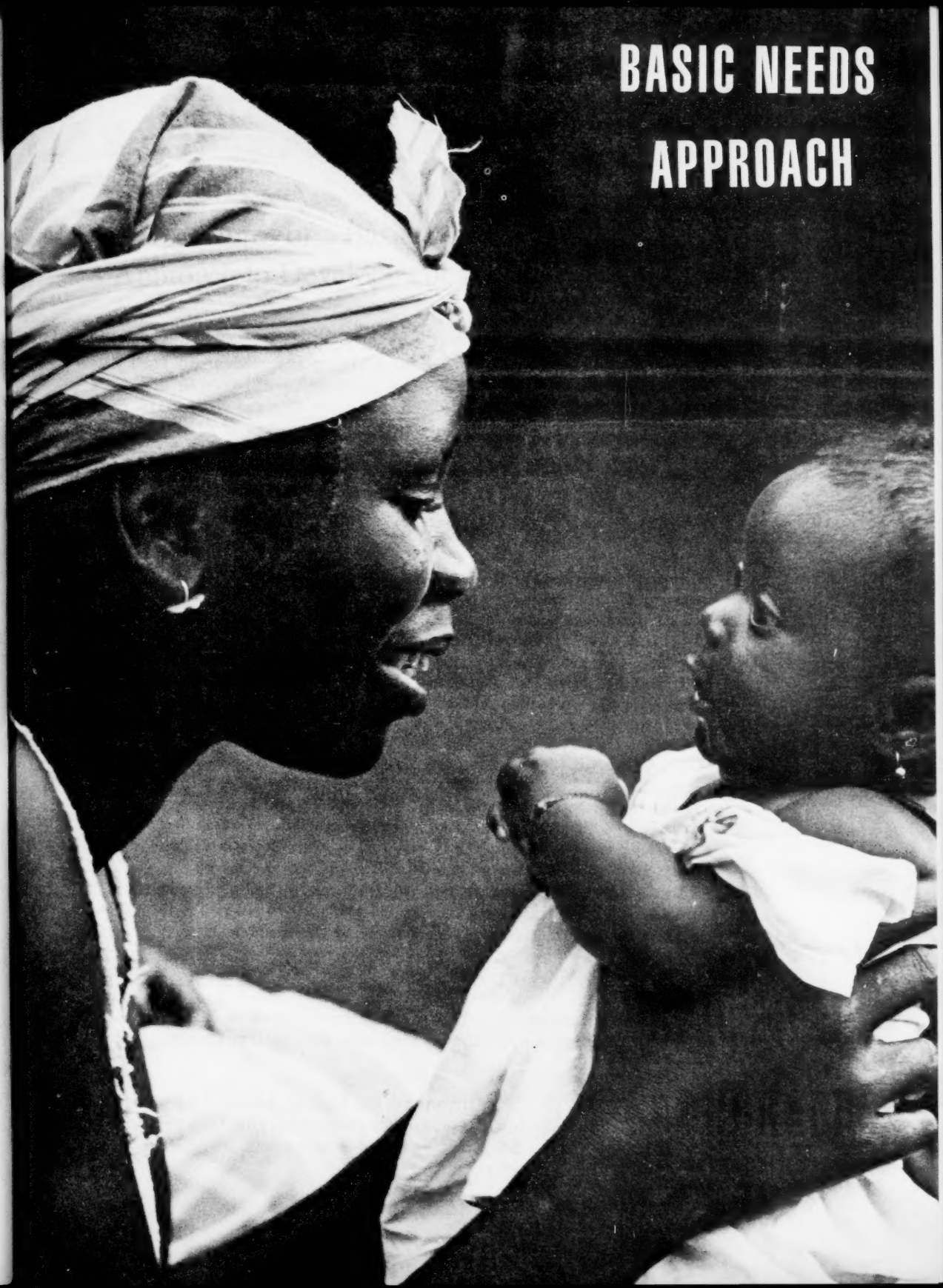
Conclusions

The recent development of Israel's arid and semi-arid areas clearly indicates that with sufficient human resources, determination and capital, modern technology can be successfully utilized to regenerate desertified areas on the fringes of the desert. Barring long-range climatic shifts, these regenerated areas can serve as a barrier to desert expansion until such time as the desert itself succumbs to man's constructive efforts. Organized into a suitable economic and social framework, these regenerated areas can support a population at levels comparable to those of more humid regions. That such endeavors can prove successful is undoubtedly the salient lesson to be learned from the Israeli experience.

It should, however, be recognized that countries involved in the effort to contain or reverse desertification should not always embark upon the same paths or utilize identical technologies. There is a fairly wide range of physical conditions within the semi-arid and arid regions, and an even wider spectrum of cultures, customs and political and social organization. Because of historical discontinuities, Israel has been able to effect a quantum jump directly into the most modern technologies. This may not be possible in other newly-developing nations. Each country has its unique social structure and physical characteristics, and the practices and techniques utilized for generations by indigenous agriculturalists should not be lightly dismissed. These practices often represent valuable experience gained over the years by trial and error, and should be improved and modified in the light of modern knowledge to a point where optimum productivity and resource conservation is obtained. However, when new settlement or development is undertaken in relatively unpopulated regions, a more radical approach may be feasible. It is especially in this latter case that the Israeli experience can be of direct consequence.

[Extracted from The Negev: A Desert Reclaimed, pp. 1-2, 23-52, 60-70, 103-4. Case study by the Government of Israel prepared for the U. N. Conference on Desertification, Aug. 29 - Sept. 9, 1977 in Nairobi, Kenya.]

Note: This report was strongly criticized at the Conference on political grounds for a paragraph of a historical nature, unrelated to the technical materials presented here.


BASIC NEEDS
APPROACH

PICTURE FROM UNICEF PROGRAM IN LIBERIA
(PHOTO: UNITED NATIONS)

Distinctive Features of a Basic Needs Approach to Development

Paul Streeten

[The idea that development goals and measures of progress should emphasize the provision of basic needs to all people is receiving increasing attention (see Development Digest, January 1977, pp. 32-42). While there is not a clear concensus on what needs should be considered "basic", most would include food, shelter, clean water, access to minimal health services and primary education; some would add more items. This article discusses a number of aspects and implications of the idea.]

The Basic Needs (BN) approach to development may be seen as the culmination of twenty-five years of development thought and experience. From this point of view, BN can be considered to have brought to bear the best components of previous anti-poverty and employment-oriented strategies such as rural development, urban poverty alleviation, employment creation through small-scale industries, "redistribution with growth", and others. But there are drawbacks in elevating BN to such an all-embracing, almost exclusive, development strategy. It suffers from political unreality, and this type of definition tends to blur the features that distinguish BN from other strategies. In this article an attempt will be made to define the differentiating features of a Basic Needs approach. If it is accepted, it becomes not the development strategy but an adjunct to, and a modification of, existing development strategies.

Objectives

BN starts from the objective of providing the opportunities for the full physical, mental and social

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development of the human personality and then derives the ways of achieving this objective. This objective can be interpreted as giving priority to the goal of a minimum income level for everyone. But the BN approach diverges from all income approaches, whether they emphasize aggregate growth, distribution norms, or minimum level targets. It focuses on channelling particular resources to particular groups, identified as those who are deficient in these resources (defined, for example, as those whose diets lack caloric adequacy). It concentrates on the nature of what is provided rather than on income. It is therefore a more concrete and positive concept than "eliminating poverty" or "reducing unemployment", or raising the growth rate of the incomes of the bottom 40 percent. It does not replace the more aggregate and abstract concepts, which remain essential to measurement, analysis, and policy; it gives them content. Nor does it replace concepts that are means to broader ends, like productivity, production and growth; from the end of meeting basic human needs it derives the need for changing the composition of output, the rates of growth of its different components, the distribution of purchasing power, and indicators of measuring impact.

In addition to the concrete specification of human needs, in contrast to abstract concepts, and the emphasis on ends in contrast to means, BN encompasses certain "non-material" needs. They are a vital component of a Basic Needs approach, not only because they are valued in their own right, but also because they are important conditions for meeting "material" needs. They include the need for self-determination, self-reliance, political freedom and security, participation in making the decisions that affect workers and citizens, national and cultural identity, and a sense of purpose in life and work. While some of these "non-material" needs are conditions for meeting more "material" needs, there may be conflict between others, such as meeting basic material needs and certain types of freedom. For other sets of needs, there may be neither complementarity nor conflict.

BN is concerned not only with the underemployed and unemployed but also with the unemployables: the aged, the sick, the disabled, and orphaned children. This group has been neglected by the income and productivity approach to poverty alleviation and employment creation. Of course, it raises particularly difficult problems of implementation, not only in poor societies but everywhere.

Income Approach Versus Basic Needs

The BN approach is contrasted with the income approach, which recommends measures that raise the real income of the poor by making them more productive, so that the increased purchasing power of their earnings plus their subsistence production is adequate to enable them to buy and/or grow the goods in the basic needs

basket. The Basic Needs approach, in the narrow sense, regards the income-orientation of earlier approaches as inefficient or partial, for seven reasons:

(1) There is some evidence that consumers are not always efficient optimizers, especially in nutrition and health; and especially when changing from subsistence farmers to cash earners. Additional cash income is sometimes spent on food of lower nutritional value than that consumed at lower levels (e. g. by substituting polished rice for coarse grains, or rice for wheat,) or on items other than food.

(2) More important, the manner in which additional income is earned may affect nutrition adversely. Female employment may reduce breast feeding and baby's nutrition, even though the mother's income has risen. Profitable new cash crops may drive out nutritionally superior but commercially inferior crops like millet.

(3) There is maldistribution within households; women and children tend to be neglected in favor of adult males.

(4) Perhaps twenty percent of the destitute are sick, disabled, aged, or orphaned children; they may be members of households or they may not; their needs have to be met through transfer payments or public services, since, by definition, they are incapable of earning.

(5) Some basic needs can be satisfied only, or more effectively, through public services (education, health, water, sanitation); through subsidized goods and services, or through transfer payments. These services call for progressive taxation, indirect taxation of luxury goods, and for a system of checks against abuse. The emphasis is on investigating why public services have so often failed to reach the groups for whom they were intended, or were claimed to be intended.

(6) The income approach has paid much attention to the choice of appropriate techniques, but has neglected the need for appropriate products. In many developing societies, the import or domestic production of over-sophisticated products, transferred from relatively high-income, high-saving economies, has frustrated the pursuit of a Basic Needs approach by catering for the demand of a small section of the population, or by preempting an excessive slice of the low incomes of the poor. The choice of "appropriate" products, produced by "appropriate" techniques, giving rise to more jobs and a more even income distribution, which in turn generates the demand for these products, is an essential, distinct feature of the BN approach, not fully achieved by a redistribution of income.

(7) Finally, the income approach neglects the importance of "non-material" needs, both in their own right and as instruments of meeting some of the material needs more effectively. This point becomes particularly relevant if the neglect of non-material needs (like partipation) increases the difficulty of meeting basic needs more than that of achieving income growth.

The selective approach makes it possible to satisfy the basic human needs of the whole population at levels of income per head substantially below those that would be required by a less discriminating strategy of all-round income growth. This point is crucial. By attacking the evils of hunger, malnutrition, disease and illiteracy directly, their eradication (or at least amelioration) can be achieved with fewer resources, or sooner, than by choosing the roundabout road of raising incomes. We may think of a "gap" between available resources and the resources required to meet basic needs, though this way of putting it is somewhat mechanical. The great merit of a BN approach is, then, that it can close this "gap" more successfully for two reasons: first, because fewer resources are required for closing the "gap" in a given time, and secondly, because it makes more resources available.

Fewer resources are required, or the objective can be achieved sooner, because a direct attack on deprivation economizes in the resources on which income would be spent, or which do not contribute to meeting basic needs. These include the non-basic needs items in the consumption expenditure of the poor; part of the non-incentive consumption expenditure of the better-off; and corresponding investment expenditures to the extent that their reduction does not detract from constructing the sustainable base for meeting basic needs. In addition, these fewer resources show a higher "productivity" in meeting basic needs: a combined operation for meeting an appropriately selected package of basic needs, e. g. water, sewerage, nutrition and health, can economize in the use of resources and improve the impact by planning advantageous linkages, complementarities and interdependencies between different sectors. A basic needs approach attempts to economize in the use of existing resources, by doing more and doing better, with fewer resources: replicable preventive medical services for all, instead of high-cost curative medicine for a few; low-cost village primary education instead of high-cost urban tertiary education for the privileged.

Further, a direct attack on infant mortality, women's education and even the apparently purist "welfare" component, the provision for old age, illness and disability, will bring about changes which are thought to reduce the desired family size and fertility rates more speedily, and at lower costs, than would be possible by raising household incomes. The causal nexus has not been established beyond controversy, but these particular basic needs have shown statistical relationships with fertility reduction.

BN will also tend to make more resources available for use in the domestic economy of a developing country for four reasons. First, the composition of output needed to satisfy basic needs is likely to be produced more labor-intensively. In countries with under-employed labor, this will raise not only employment but also production. Secondly, an attack on malnutrition, disease and illiteracy not only lengthens life and improves its quality but also improves the quality of the labor force. (It is, however, a complex question whether the returns to this form of human investment are higher, at the margin, than those from more conventional investment in physical capital.) Thirdly, the removal of motives for large families, by an attack on the "correlates of fertility decline" mentioned in the previous paragraph, can be regarded as a factor reducing the resources needed to sustain a given standard of living because the population will be smaller. Fourthly, a BN approach that is based on enhancing the "participation" of poor people in decision-making will mobilize local resources and increase incentives for higher production.

More resources might also become available from foreign sources because the pledge for meeting the basic needs of the world's poor has stronger moral and political appeal in aid-donor countries than most other schemes advanced for the promotion of international assistance. A U.S. public opinion survey found that the majority of people do not support general "welfare" programs, but at the same time do support specific measures, like helping poor families with deprived children. Similarly, "development aid" is less appealing than help in meeting basic needs. There can be no certainty about this, but it is already clear that the concept has international appeal, and it may help to overcome the present aid fatigue by defining new forms of international cooperation and commitments. Since food is an important element in BN, and since, given the distribution of votes in Western democracies, food aid is politically easier than most other finance, properly channelled food aid could make an important international contribution to meeting BN.

It remains to be investigated how a BN approach is likely to affect specific resource constraints, like foreign exchange, administrative skills, etc. It might be thought that BN would reduce exports, for example, but it would also tend to reduce import requirements. It would certainly call for more administrative skills; but if local incentives and efforts can be harnessed, motivation for raising the supply of these skills would be strengthened, especially as these skills need not be of a very high order.

In brief, therefore, a BN approach, because it saves resources, because it mobilizes more resources, and because it makes these resources more productive, can achieve an agreed priority objective

with fewer resources, or sooner, than a solely income-oriented approach. But two crucial questions remain: one of value and one of fact. The value assumption underlying the above argument is that zero weight (or at least substantially lower weight) is attached to the uses of all extra resources that do not meet basic needs. It may be objected that governments and people who do not accept this value judgment will reject the whole approach, and those that do, won't need it. But governments and people do not have monolithic value systems. The crucial factual assumption is that leakages or "trickle up" in a selective system are smaller than in a general system. But if the benefits of basic need allocation systems do not effectively reach the needy, the "wastage" in the BN approach may be as large as, or even larger than, that of the income-oriented, non-selective approach. This is an important area for operational research and experimentation.

The Politics of Basic Needs

It is sometimes argued that BN is an ideological, polemical, religious or emotive concept that conceals a call to revolution. Such an interpretation can be justified neither historically nor analytically. It is evident that a wide variety of political regimes, like those of Japan, Israel, Costa Rica, Taiwan, Korea, the People's Republic of China, Yugoslavia, Sri Lanka and others have satisfied basic needs within a relatively short time. To be sure, the success of these different political regimes in meeting basic needs cannot be attributed to their having written BN on their banner. But they share certain "initial conditions" in the distribution of assets, levels of education and health, etc., and a set of policies that present important lessons to others attempting to meet basic needs. These countries started from a base at which some basic needs for health and education were already satisfied, which obviously reduced the time required for meeting basic needs, both directly, and through their indirect effect on the quality and motivation of the labor force.

While some political regimes have succeeded in satisfying basic needs within a short period without adopting the BN approach as an explicit policy instrument, others have paid lip service to the objective but without succeeding in implementing it. The reasons for this gap between professions and practice are, ultimately, political. To some extent governments lack the knowledge and administrative power to meet basic needs. Rural development and anti-poverty programs are far more difficult to administer than those for the urban elite; governments are often capable of administering complex programs of import restrictions or investment licensing (where the protection of the privileged is in question) with greater efficiency than they can achieve in bringing clean water or new farming methods

to the countryside. Neglect might also be partly explained by the system of incentives and the type of technologies considered to be essential to a development strategy as traditionally conceived. But neither administrative weakness nor incentives and technology can fully account for what must ultimately be attributed to absence of a political base. High marginal tax rates paid by very few, and land reform legislation on paper that remains unimplemented, are the result not so much of administrative weakness as of the fact that the poor do not have as strong a voice as the richer members of society.

If the failures of past strategies are due to vested interests and to the political obstruction of those who would lose from a basic needs approach, how can these forces be kept in check? In many regimes the poor are weak bargainers, and are not a political constituency. But measures to meet basic needs could, in some situations, be implemented by a reformist alliance in a peaceful manner. Some of these measures are clearly in the narrow self-interest of the dominant groups, like the eradication of communicable diseases or the preservation of social peace. Others are in the longer-term interest of some groups who would have to mobilize support for gradual reform; urban industrialists and workers, for example, may support a land reform benefiting small farmers and landless laborers if this promises more food in the cities.

It is possible, however, that mobilization of the rural and urban masses, required for this gradualist approach, could initiate a revolutionary process which the initiators of the mobilization process may regret. The conditions in which this is liable to happen, and the conditions in which a grass roots democracy on a pluralist model would emerge, have received almost no attention so far. Nor have the macroeconomic implications of the transition from the present state to one in which basic needs are met been thoroughly investigated. Inflationary pressures, capital flight, brain drain, strikes by disaffected groups may present obstacles in the path of implementation. Whatever the route to be followed, the proponent of a BN approach, having identified the political, administrative and institutional obstacles to fulfilling basic needs, must specify how the constraints are to be removed.

Implementation: Channels and Leakages

Some critics of the BN approach share the goal of meeting BN but object that, unless specific steps are spelt out that lead to their satisfaction, it cannot be called a strategy. This is entirely valid; as yet there is nothing that could be described as a fully articulated BN strategy, even as an adjunct to other strategies. For those

who agree on the objective, the conclusion ought to be that there is need for urgent further work in areas of ignorance, and for experimentation with a wide variety of approaches so that experience from pilot projects is gathered for replication.

Among the many areas in need of clarification is the question whether meeting basic needs directly is more promising than doing so indirectly. Certain types of indirect approach, such as "trickle-down" from a concentration on sectors with high commercial returns, and the resulting high total income growth irrespective of its composition and distribution, have been discredited. But others remain to be explored. For example: if we are concerned with the bottom 40 percent of rural incomes, would it be better to concentrate on those who are potentially viable farmers, and hope that out of their higher production welfare payments for the poorest 10 percent will become possible, or that more employment opportunities will be generated? Or should the needs of the poorest be met directly and immediately? The importance of channeling particular resources to particular groups does not imply that some indirect ways of channelling them may not be more effective than direct ways.

The study of how public services can reach the poor, and how the poor can mobilize their own efforts to make these services effective, is still in a rudimentary state. The questions it has to answer are: How can we ensure that public revenues, when devoted to public services to meet BN, actually reach the vulnerable groups? How is access to the bureaucracy secured? What are appropriate priorities in the line of applicants? What system of checks against abuse, and of monitoring to ensure success, are required?

While social services for the poor and their biased impact have received a good deal of attention, the biased impact of many systems of taxation has been neglected. Either taxes do not exist, or nominal taxes are not collected, or, where they are collected, their ultimate incidence is shifted onto those least able to bear them. A thorough scrutiny of the system of collecting revenues and the incidence of taxation from the point of view of meeting basic needs is as important as one of examining the incidence of public services.

Complementarities and Trade-offs

The improvement of nutrition, or of water supply, or of sanitation, or of health services, each in isolation, may have a smaller impact on the mortality or morbidity of a poverty group than a concerted attack. Without adequate nutrition, resistance to diseases will be lower and the cost of a health program higher. Without the elimination of gastro-intestinal diseases, nutritional requirements are higher.

Without safe water, control of communicable diseases and improvements in public health, nutritional programs are unlikely to have permanent benefits. There is evidence that family planning programs are more effective if combined with nutrition and health measures. The benefits of education in raising the effective impact of all other services is obvious; but equally, improved nutrition of children enables them to benefit more from education.

Certain linkages between different public services reduce costs; others increase the impact. In addition, there are important and sometimes neglected linkages between private income and access to public services. Parents have to have adequate incomes before they can afford to spare their children from work and send them to school; and they need money to equip them with books, properly lit rooms and transport. The sick must be able to afford to travel to clinics.

While a "Big Push" or concerted attack on several fronts at the same time would be more effective, resources are scarce; and policies therefore have to be selective. There may be trade-offs between, say, eradicating malaria and some other operation. In such cases a "vertical" or spearhead approach would be more appropriate than a "horizontal" approach. This implies that the quantification and comparison of the costs and the benefits of these services must be conducted in terms of selective packages. The implications for project appraisal are clear: costs per unit of a given public service may (or may not) be reduced if the service is combined with others, and if the impact on health, education, nutrition or family planning can be raised by such a combination. For some purposes "balanced growth", for others an "unbalanced" attack, may be the more economical.

Technologies, Participation and Administration

The cost of providing for basic needs will vary over a wide range, depending on the technologies used. But technology, in turn, will depend on the degree of local initiative, commitment and participation, the amount and quality of local factors of production and materials mobilized, and the local cultural attitudes and social institutions. The managerial and administrative framework for implementing BN is crucial for its feasibility and costs. Much is talked about the need for "participation" and "self-management". The important questions, however, relate to the precise combination of central leadership, central coordination and central resource contribution, with decentralized decision-making and mobilization of local resources (especially underemployed, low-cost labor) which would, in specific circumstances, be most effective.

Past calculations of BN requirements have often started by counting those in need and estimating the cost of eliminating their deficiencies. The counting was often wrong (with a poor data base), and the standards of what was supposed to be supplied often ill chosen. The resulting bill for "needed services" was exorbitant; and in practice, the attempts that resulted rarely succeeded in reaching the poor. Planning for BN should: set standards that are appropriate to actual conditions and allow for the wide interpersonal and inter-temporal variations in human requirements; it should pay attention to what can be afforded by the use of appropriate technologies; it should pay attention to social and cultural forces, mobilize local resources, and concentrate on processes and sequences that meet the needs of the poor. The correct approach is still largely unexplored.

[Extracted from International Development Review, Vol. 19 No. 3, 1977, pp. 8-15. Copyright © the Society for International Development, Washington, D. C.]

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*U.S. GOVERNMENT PRINTING OFFICE : 1978 O-261-404/1